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JOURNAL

OF THE

Franklin Institute,

DEVOTED TO

Science and the Mechanic Arts.

EDITORS

PROF. HENRY MORTON, PH. D.

AND

W. H. WAHL, PH. D.,

ASSISTED BY THE COMMITTEE ON PUBLICATIONS.

Vol. LXXXX.—No. 535.

THIRD SERIES.

Vol LX.—JULY, 1870.—No. 1.

PHILADELPHIA:

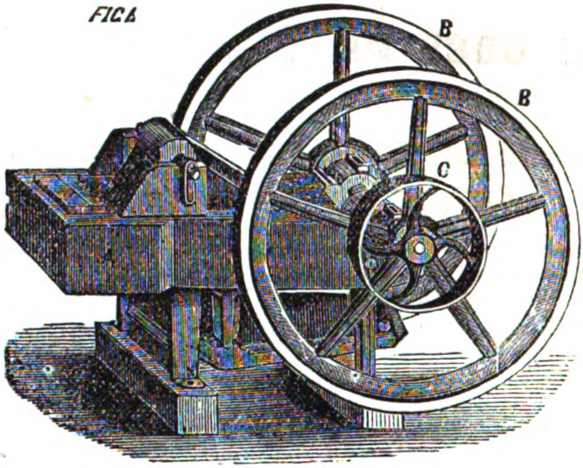
PUBLISHED BY THE FRANKLIN INSTITUTE AT THEIR HALL.

1870.

BLAKE'S

STONE BREAKER.

FIG. 1



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THE

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OF THE

of Pennsylvania —

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1870.

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(~~IX~~. 2-6.)
1875, March 25.
Farrar Fund.

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OF THE

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LX.] JULY, 1870. [No. 1.

EDITORIAL.

ITEMS AND NOVELTIES

Band Re-Sawing Machine.—We illustrate in this number a machine for re-sawing lumber, from the designs of the manufacturers, Messrs. Richards, Thorne & Co., of this city.

The extraordinary waste that has always characterized our lumber manufacture has at last, through its increased value become a subject of much consideration.

Lumber has doubled its value in ten years, notwithstanding the great improvements in log cutting machinery, which, together with increased facilities for transportation, has done much to cheapen its production, it has steadily continued to advance in price. Many staples have, since the war, fallen to former prices, and some are even cheaper, all things considered, than in 1860; but lumber is an exception, and when we come to consider the conditions that

control its value, it is fair to presume that it will continue to rise in price.

The waste of lumber in the United States is almost "criminal," to use a strong expression. The ordinary one-inch boards of commerce represent but little more than three-fourths ($\frac{3}{4}$) of the stock from which they are cut (we mean after it is squared) or less than one-half the round log. A great share of this waste comes from the *saw kerf*, which is from $\frac{1}{4}$ to $\frac{5}{16}$ inch, and in some cases, even $\frac{3}{8}$ inch wide.

In Europe they economize in this respect by cutting their round logs into deals or thick planks, in the forest, to be reduced by re-sawing machinery when the lumber is manufactured. These deals come from the Baltic, Canada and other points, and in England and on the Continent, are the lumber of commerce.

In re-sawing these deals, there is saved at least one-half the kerf of our saws by using thinner blades—the lumber is clean and bright—the machines are so constructed as to give accurate dimensions to the stuff and save the usual allowance for shrinking, warping and planing that has to be made in forest cut lumber. We are well aware that there are many conditions that prevent the adoption of such a system here,—but we should consider it—select what is good and applicable to our wants. We should re-saw more lumber, use thinner saw-blades, and saw our stuff more accurately. This seems to be one of the most practical as well as one of the most important reforms that can be made to economize.

The limited amount of re-sawing that has hitherto been done, has not been sufficient to warrant machine builders in producing in this country, machines to correspond to the Deal Frames of Europe. Re-sawing machines of this kind are too expensive, and we find as a rule that the little re-sawing done is with a single reciprocating blade, and necessarily so slow as to enhance the cost of the lumber to an extent that balances the gain. It is true that circular saws can be used, and are used for splitting flexible stuff of limited depth, but can only be considered as auxiliary in re-sawing generally.

The history and success of the Band Saw now warrants a belief that we will soon be able to avoid this waste of kerf in lumber cutting, and to construct machinery for re-sawing and slitting at a moderate cost.

Perin, of Paris, has for years been making band sawing machinery for all kinds of lumber manufacture—re-sawing, log-sawing,

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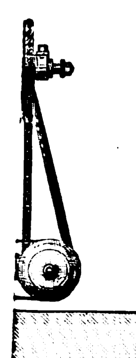
Plate I.



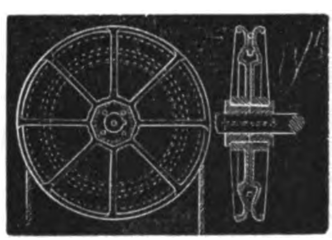
and scroll-cutting. His mills although of very light proportions are running now in this country, cutting South American timber that would almost defy our sash and circular saws, cutting through, in some instances, a depth of 5 feet of hard wood. His re-sawing machines are generally used on the Continent.

A. Ransome & Co., of London, England, are now building band saw machines for re-sawing with a continuous feed of 30 feet per minute. With these facts before us, the capacity of the Band Saw for re-sawing need hardly be questioned.

The machine we illustrate is strongly framed with about 2½ tons metal, the wheels are 48 inches diameter, with 4½ inches face, intended to carry blades from 2 to 3 inches wide, and 28 to 30 feet long. It is arranged with double pairs of strongly geared feed rolls (all driven) and contains many of the patented improvements of the manufacturers, among which are their *improved guides* for supporting the blade, which we had occasion to notice in a former number of the *Journal.* All possible effort has been made to simplify and reduce the cost of the machine, except in workmanship and strength, which are always cheapest when best.

The feeding frame is detached from the mill proper, and being mounted on an independent planed sole-plate, can be removed to substitute a common slitting bench, or a log carriage for round timber, &c.

Kelsey's Patent Wedge Driving Drums and Pulleys.—"On reference to the illustrations it will be seen that these pulleys are intended for transmitting power by means of wire ropes, the rope being held firmly between the sides of the pulley, and thus preventing 'slip,' a difficulty hitherto felt by colliery engineers and others, whose operations rendered the use of wire rope necessary. These pulleys are extremely simple in construction, and consist of two loose disks, an internal wedge ring, and a boss or nave divided in the centre transversely, all the castings being of an ordinary and inexpensive character. The cuts give a section and a side elevation. The two disks are made with an angular recess, on the inner face of each, and the centre holes are cut, slightly curved transversely, and made to fit with ease the octagonal boss.



The internal wedge ring is made with a straight point, the periphery being concaved to receive the rope, and in order to allow for wear upon the latter the point is also made of less thickness than the diameter of the rope. The nave or boss is provided with a flange cast on each end, which flange is for the purpose of retaining the disks in position. The nave is faced and bolted together, and bored out to fit the driving shaft, to which it is secured by means of two short keys driven from each end. The action of the pulley is brought into operation by means of the pressure of the rope being thrown on one side of the pulley, upon the internal wedge ring, which is thereby forced against the inclined faces of the recess in the disks on the other side of the pulley, the result being that the disks are driven apart on the bottom side, and towards each other, so as to compress the rope on the top side." J. H. C.

Beale's Improved Grease Injector.—We copy from *The Engineer* of April 8th, 1870, p. 202, the above device. Fig. 1 is intended to stand upright and receive charge of grease into the hollow plunger P, when the hinged or screwed top T is raised. On withdrawing the plunger a valve V opens, allowing the grease to pass through. When the plunger is forced back into the case the grease is forced by the lower valve, V, into the place where it is wanted. Both valves are held to their seats by spiral springs.

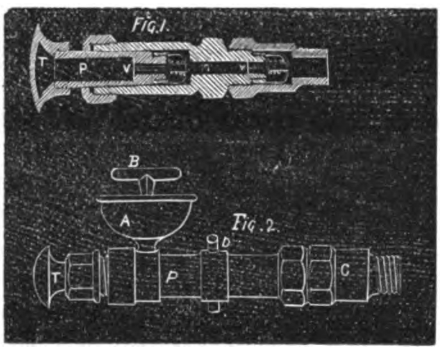


Fig. 2 shows a form which is used horizontally. It has but one value which is in case C, the same as in Fig. 1. A is a bowl for receiving a charge of grease; B is a key for allowing the bowl to empty itself into P, and D a vent key. When D and B are open, and the solid plunger T withdrawn, the grease flows from A into case P. When B and D are closed, and T forced into case P, the grease is injected the same as with Fig. 1.

One advantage these injectors possess is the facility and certainty with which liquid lubricants can be projected upon bearing surfaces within steam chambers as those of journals, slide-valves, pistons and the like.

Induction Coil of Unusual Size.—An induction coil of great power has recently been constructed by Ritchie & Son, of Boston, for Dartmouth College, the most powerful one at present in the country. It has not yet been tried with a battery sufficient to develop its force, but has given a torrent of sparks of between 19 and 20 inches in length when excited by the battery of 24 pairs of large zinc and iron plates immersed in dilute sulphuric acid, which is used by Mr. Ritchie in magnetizing compass needles and other similar work.

With 9 cups of medium-sized Bunsen elements, arranged 3×3, it gives an 18-inch spark; with a single cup it gives 6 inches.

The apparatus consists, really, of two independent coils, which are placed on the same base, with their axes horizontal and coincident, and are capable of being used separately or in combination. Either section alone gives, readily, a 12-inch spark. They can be combined *for quantity*, giving in this case, of course, no greater *length* of spark than when used singly, but producing luminous effects of remarkable beauty; or for *intensity*, and in this way the long sparks, spoken of above, are obtained.

The length of each section is 15 inches, and its diameter 8; the whole machine being a little over 3 feet long.

The cores of fine annealed iron wire weigh 11 pounds; the primary coils are of copper wire, $\frac{1}{8}$ of an inch in diameter and 185 feet long; the secondary coil is of wire $\frac{9}{1000}$ of an inch in diameter and 183,000 feet long, or very nearly 35 miles.

The condenser has a coated surface of 225 square feet, divided into three sections of 80, 80 and 65 feet respectively. Instead of being placed in the base of the instrument, as is usual, it is mounted in a separate case, upon which is also placed the break circuit apparatus, which is either automatic or not, at pleasure. This arrangement was adopted to avoid the danger of getting occasional shocks as would be very likely to happen were the operator's hands so near the coil as would be necessary in manipulating an instrument constructed in the ordinary manner. The whole machine is beautifully finished, and in every way creditable to its makers. Its cost was a little over $700. Y.

Millimetre Ruled Paper.—Having, on several occasions, suffered inconvenience from the uncertainty of being able to procure this scale for mapping spectra and other work, or from the impossibility of obtaining it without the delay of importation; and hav-

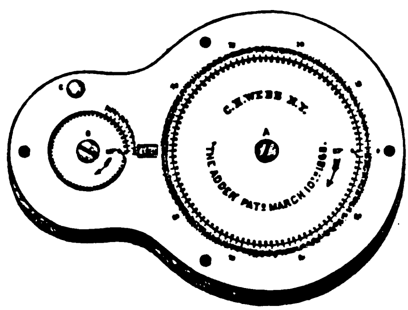
ing, at intervals, received from our contributors, the assurance, in the form of similar work on improvised paper, that they experienced the inconvenience equally with ourselves, we beg leave to state that we have obviated the difficulty for the future, by having the scale lithographed, in order that we may be able to print it in sheets, as we have need for them. A specimen sheet appears as a plate accompanying this notice that those interested in the matter may test its accuracy. Our contributors and subscribers for whose convenience this was done, can have it as they need it. The price charged will be the simple cost of meeting the order.

Machine for Addition.—By C. H. Webb, of New York.—This very simple and efficient piece of mechanism is represented by Fig. 1 in its exterior appearance, and by Fig. 2 as regards its internal mechanism.

In the first place, as regards the exterior, A, Fig. 1, represents a plate with 100 holes around its periphery within a divided circle having 100 degrees in its circumference.

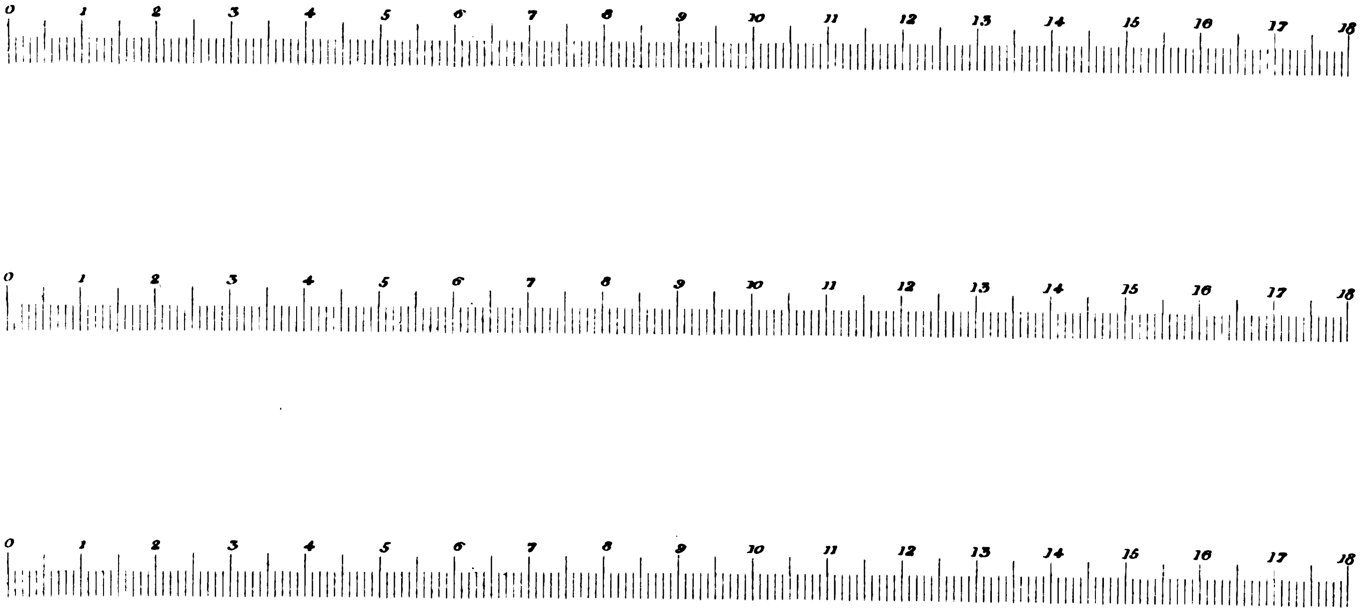
A small steel point being inserted in one of the holes, enables us to rotate the disk in the direction of the arrow until motion is arrested by the steel point coming to the stop at O, where the small hand points in the figure. Suppose the disk set with this hand and O point of the disk opposite the O of the divided circle, and suppose that the steel point is now inserted opposite the figure 10 of the outer circle, and the disk moved until the point strikes the stop. The disk will clearly be moved around a distance corresponding to 10 holes or divisions, and an outer rim of the same which lies under the divided circle, and is numbered from 0 to 99, will show 10 at the open slot between the two circles where O O is seen in the Fig 1. If, in turn, the steel point is inserted at the hole now opposite 15 of the scale, and moved to the stop, the disk will be moved forward by 15 more stops, and the figure exposed at the slot will be 25. When the distance moved forward amounts to 100 divisions and numbers, then, by mechanism to be presently described, the smaller disk to

Fig. 1.



Millimetre Scale for mapping Spectra.

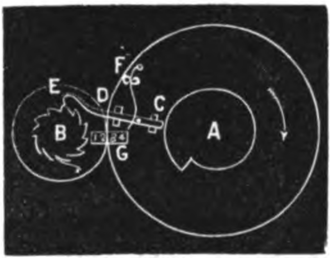
Plate I.



the left advances one step and shows figure 1 through the same slot in the place for hundreds, the numbers on the larger disk appearing over again in their former order of 0 to 99.

The mechanism by which this motion of the second disk is obtained may be seen from Fig. 2. A is a spiral cam which is connected with the disk having the 100 round holes in it, and which being rotated in the direction of the arrow forces the sliding catch, C E, out against the pressure of the spring, F, until a complete revolution is accomplished, when the catch dropping into the re-entrant angle of the cam engages a tooth on the second disk, B, and moves it forward one step or number. There are 50 teeth on B (although only a few are shown in the cut) corresponding to 50 numbers on the edge of its disk. The highest number which the machine will record is thus 5099, which is, however, quite as much as any column of two figures of average numbers will make, even if it be 100 lines in length. Having added one pair of columns, we then set the disks so as to bring the numbers to be "carried" into view in the slot, and proceed with the next pair of columns as before.

Fig. 2.



The agency for this instrument, in this city, is in the hands of Messrs. Moss & Co., 432 Chestnut street.

The U. S. Naval Observatory.—It is a surprising, and, at the same time, a mortifying fact, that one of the most important of our national establishments—an establishment devoted exclusively to scientific investigation and discovery, and to the propagation of its useful knowledge so accumulated, and which, under intelligent patronage, might be made cosmopolitan in its labors and achievements—should be so inadequately supplied with working material that the best talent of the land would be literally thrown away in the attempt to maintain a rivalry with the splendidly equipped and liberally patronized national establishments of a similar character abroad.

We refer to the inadequacy in the equipment of the United States Naval Observatory at Washington, and more especially to the inefficiency in the quality of its equatorial telescope. Not only is our national observatory unable to enter the scientific arena

against those of other nations, and to partake of the brilliant successes which are adding fresh lustre to the names of France and England, but even in our midst there are at least three telescopes in the possession of private citizens, besides many others belonging to our institutions of learning, of superior power to that of the nation.

In view of this anomalous state of affairs, it is gratifying to learn that a number of our most eminent men of science have interested themselves in the matter, and, imbued with the desire of placing our National Observatory upon a footing which becomes a great and cultivated people, and of giving to the nation's astronomers an equal chance with others, have, in the form of a memorial, called the attention of Congress to the condition of things here mentioned.

In his last report to the Naval Department, the Superintendent of the Naval Observatory dwelt strongly upon this pressing want, as well as upon the fact that the most successful living constructor of telescopes (Alvan Clark, of Cambridge, Mass.,) was desirous of receiving an order for the largest refractor in the world, which should cost $40,000.

The coincidence of the opportunity which Mr. Clark now possesses of undertaking this great work, and of the urgent necessity of doing something to render our observatory worthy of the name it bears are favorable auguries for the fulfilment of this much-to-be-desired "reconstruction."

The Ammonium Amalgam and Hydrogenium.—We have received through the kindness of Dr. Wurtz, editor of the *American Gaslight Journal*, an early proof of an abstract from an original communication on the above subject, by Prof. Charles A. Seely. The general conclusions of the author, as will be seen, are opposed to the existence of the ammonium amalgam as such, as also to that of the hydrogenium amalgam of Loew.

Dr. Wetherill, who was one of the first of the few chemists, who opposed themselves to the ammonium theory, published in *Silliman's Journal*, Vol. XL., p. 160, (to which the reader is referred,) the following conclusions as the result of quite an extended series of experiments upon this subject.

1st. The so-called ammonium amalgam is not an alloy of mercury with ammonium.

2d. The swelling at the mass in the phenomenon is due to the retention of gas bubbles, and

3d. The coherence of the gases and liquids concerned is changed from a normal condition, exhibiting phenomena, which may be classed with those of catalysis.

The results of Prof. Seely's investigations, which are both original and ingenious, afford a confirmation of this view, while his communication must be regarded as a valuable addition to the literature of the troublesome amalgam. The following summary will serve to indicate its tenor.

"The author considers the so-called ammonium amalgam to be a mechanical or physical mixture of liquid mercury with the gases ammonia and hydrogen, and that its semi-solid consistence is due to the mixture having the nature of a froth. When sodium amalgam is brought into a solution of sal-ammoniac, the chlorine combines with the sodium, and the residue ($N\ H_3 + H$) of the sal-ammoniac is set free all over the surface of the mercury in minute bubbles, and by reason of the movement bringing to the surface fresh mercury which is acted upon in the same way, the mixture becomes a homogeneous froth."

The author reaches this view of the composition of the amalgam from the following considerations.

1st. The volume of the amalgam is inexplicable in any other way; it is utterly inconsistent with the well-established laws of combination by volume. No case of a liquid or solid chemical compound, has any analogy to it.

2d. Mercury has a mirror like surface, while the amalgam has comparatively a whiter and more dead surface, and approaches in appearance to matt silver. Such changes are characteristic of froths.

3d. The amalgam when subjected to varying pressures, suffers changes of volume apparently in accordance with Marriotte's law of gas volumes.

From these considerations the author draws the conclusions,—that the ammonium amalgam is no amalgam at all, and that the existence of the metal ammonium has not been proven. He likewise urges similar considerations in objection to the hydrogenium amalgam of Loew, and to the palladium-hydrogen alloy of Graham.

A Rain of Solid Matter.—*Cosmos* contains a notice of a remarkable rain of yellowish matter which fell at Genoa, during the morning of the 14th of February, 1870. The information is communicated by M. G. Boccardo, Director of the Technical Institute,

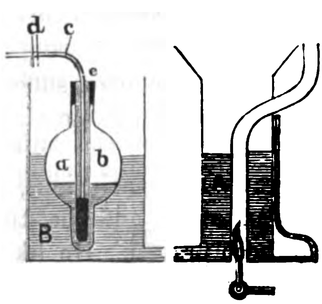
of that place, and Prof. Castellani, who together made an examination of it. The quantitative analysis gave as result:

Water	6·490
Organic matter	6·611
Siliceous and Argillaceous sand (the latter in small quantity)	65 618
Oxide of Iron	14·692
Carbonate of Lime	8·589
	100·CO

The microscope revealed the presence of numerous spherical or irregularly ovoidal globules, of the color of cobalt-blue, corpuscles resembling the spores of *Permospore:* corpuscles of a pearly color, with concentric zones, greatly resembling grains of starch, fragments of *Diatomacea*, &c.

Continuous Water-Bath.—An apparatus of this kind, fully meeting all demands upon it, was some time since designed by Prof. Bunsen, who has abundantly stocked his laboratory with these, now, inispensables; which are only excelled for convenience and in saving of time and labor, by the well known filtering-pump. The want of just such a contrivance as this will have been felt by every chemist.

The method he adopts, is to maintain a constant water level in a reservoir, which has free communication with one, or with any number of the baths. In the accompanying cut, A is the bath in cross section; composed of an outer copper cylinder through the centre of which runs a small tube of the same material, emerging at the upper end of the cylinder beneath a large flue. In the lower part of the cylinder an ordinary burner is permanently fixed, which heats the bath, and the products of its combustion are thus safely carried off. The upper part of the cylinder is fitted to receive a large funnel, in which the capsules, &c., of various sizes, containing the material to be evaporated, are placed; the watery vapor escaping likewise under the flue.



The lower end of the cylinder is furnished with an outlet upon each side,—one connecting with an open glass tube, attached to its side; to indicate the level of the water within, and the other connecting with the reservoir B.

This, the essential portion of the contrivance, (shown in cross section in cut,) consists of an outer glass vessel, B, containing water, in which floats the bulbed tube, *a*, within this again stands a tube, *b*, open above like *a*, and containing some mercury. A tightly fitting caouchouc ring, between the two, holds *b* in its place, and prevents any communication with *a;* and lastly, within *b* is a small tube, *c*, connecting with the water main, and dipping somewhat into the mercury of tube *b*. The tube *c* is held immovably in its place by clamps indicated at *d*, and does not partake of the up and down motion of the tubes *a* and *b*, about to be mentioned.

The various parts having now been given in detail, it only remains to consider their operation.

The water in A and B being in communicating vessels is at the same level in both; but the instant the flame lowers the level in A, by vaporizing its contents, it is restored by the influx of water from B. The loss of water in B would leave less to buoy up the float, which consequently sinks. In the sinking of the float, however, the opening of the tube *c*, (which is immovable,) is left under the pressure of a smaller column of mercury, and when the sinking has reached a certain point, the pressure of water from the main becomes greater than the opposing pressure of the mercury. Water flows from it, bubbles through the metal, fills the tube *b*, and overflows at *e* into the reservoir B. The increase of water in this, gives increased buoyancy to the float; it rises, the opening of the tube *c* is plunged deeper into the mercury, the increasing pressure of which, prevents further flow from the water main. The original level has now been regained, and equilibrium restored; but only to be destroyed again, by the continued action of the lamp, vaporizing the water in A, which brings about the indefinite repetition of the process just described in detail.

The height to which it is desired that the water in the bath shall stand, can be regulated in various ways; either by loosening the clamps at *d*, and closing them again, after giving to the opening of tube *c*, a permanently higher or lower position than it had previously occupied; or, by adding to or taking from the mercury in *b*, &c.

It need scarcely be stated that one reservoir can be connected with quite a number of baths, by carrying a water pipe behind them and allowing a separate tube to lead to each bath. This contrivance is, as its name indicates, entirely automatic. Material can be left upon it over night; or for days together, without requiring the constant attention, replenishing of water, &c., which make the use of the old, time-honored instrument so often troublesome and delaying.

Editorial Correspondence.

Editors Journal of the Franklin Institute.

SIRS:—My attention was called by an abstract in the *Chemical News* to the article by Mr. C. P. Williams, in a late issue of your *Journal*, upon a variety of gossan, containing cobalt and nickel, supposed to be peculiar to the outcrops of auriferous veins in Venezuela. If Mr. Williams will refer to the *American Journal of Science*, Vol. XXVII., page 24, he will observe that what appears to be *identically the same thing*, is abundant in similar geological relations over large tracts of country far nearer home.

Indeed, it is very curious, that while the aggregate of the cobalt and nickel oxides in Mr. Williams' analysis is 13·95 per cent., that of my analysis of the North Carolina gossans, as given in the extracts below, was almost the same, 13·26 per cent. The other constituents also appear to be nearly the same in each case. Not having at hand the volume of Silliman, I quote from the proceedings of the *Association* for 1858, to which body my paper was read. Excuse the length of my extracts, which seemed to me justified by the renewed interest with which the subject has been invested by Mr. Williams' communication to you. HENRY WURTZ.

No. 26 Pine Street, New York. June 20, 1870.

(From the Proceedings of the *American Association* for the Advancement of Science, Baltimore Meeting, April, 1858, pp. 221 to 227.)

ON THE OCCURENCE OF COBALT AND NICKEL IN GASTON COUNTY, NORTH CAROLINA.

BY PROF. HENRY WURTZ, of Washington.

In an exploration of a large tract of land in Gaston and Lincoln Counties, N. C., during the last summer, I found indication of the existence of ores of cobalt and nickel, in important quantity, throughout a considerable extent of country.

The region explored comprised a range of rocks composed of alternating strata of talcose and quartzose schists, which crosses the south fork of the Catawba river a little south of the line between Lincoln and Gaston Counties, and just above the falls known as the "High Shoals of the Catawba." The general direction of this

range, which forms a well-defined belt of many miles in longitudinal extent, is about N. 20° E., and at the High Shoals it is three or four miles wide. It is everywhere traversed by "veins" of quartz, carrying pyrites or other sulphides, and showing at the surface the limonite *gossans* derived from their oxidation. * * * * * *

I chiefly omit here several paragraphs, in the course of which it is stated, that on this range lie the Shuford and Cansler gold mines, and the iron mine called the "Graham Ore Bank," in Lincoln County; the "Long Creek Gold Mines," from one of which, known as the "Asbury Shaft," much gold has been obtained, and further southwest several iron mines, called the "Costner Ore Bank," the "Alison Ore Bank," the "Ormond Ore Bank," and "Briggs' Ore Bank." Still further southwest, in South Carolina, the celebrated Kings Mountain Gold Mine. The paper then proceeds as follows: " * * * Throughout the whole range, wherever examined, the talcose schists were found to contain in numerous places, small seams, incrustations, and stains of a black substance, which gave blow-pipe reactions for *cobalt.* At every one of the mines above mentioned, the ore, or refuse material thrown out, was found to be more or less coated with this substance. At the Ormond Ore Bank, particularly, so much of this substance was found mixed with the ore, that it is probably connected with the reputation of the iron produced from the latter, for hardness and toughness, throughout the surrounding country. At the Long Creek Mines also, Asbury shaft, the masses of quartz thrown out from the vein were found thickly incrusted with mammillary masses of this *wad,* or earthy cobalt. It cannot be doubted that it is the gossan of some cobaltiferous sulphide existing unaltered in the rocks below. If this substance has ever attracted the attention of mineralogical explorers in this section, it has probably been taken for earthy manganese, from which, however, it may readily be distinguished by being very soft, smearing the fingers, and, when cut with a knife, exhibiting on the section a bright black lustre, like that of massive graphite; and to these properties it owes the designation of "black lead," by which it is known among the people of the country (to whom it is familiar).

At a spot about a mile in a north-easterly direction from the Long Creek Mines, I found, crossing the road from Lincolnton to Yorkville, in South Carolina, where the latter passes over an elevation called the "Cross" or "Paysour Mountain," the

outcrop of a large "vein" or stratum of the rock, which contains very much of this black gossan or wad. It can scarcely escape the attention of a person traveling along the road, as it appears like a broad, black band at the side of the latter. At this spot it measures about fifteen feet in width. * * * Following the vein northerly from the road, the outcrop was found to descend rapidly along the western slope of the Cross Mountain; and at about a quarter of a mile from the road was found a spot where the ground consisted, in great part, of fragments of the cobaltiferous gossan.

Openings made here would probably lead to interesting and valuable developments. A determination of the quantity of mixed oxides of cobalt and nickel contained in the substance found at this spot, gave 13·26 per cent. The presence of oxide of nickel in considerable quantity in this mixture was proved by the method of Liebig. * * This Cross Mountain gossan was found, by qualitative analysis, to contain, besides *cobalt*, *nickel*, *manganese* and *iron*, small quantities of *copper*, *bismuth*, *zinc*, *lime*, *alumina*, *magnesia*, and *glucina*. * * With regard to the presence of *bismuth* in these substances, I may recall to memory the recent announcement by Dr. Genth (*American Journal of Science*, XXIII., p. 427), of the discovery of *bismutite* in specimens received by him from Gaston County, N. C., although the precise locality of these specimens is not given by Dr. Genth. The Asbury Shaft and Cross Mountain minerals give deep, beautiful, grass-green solutions in hydrochloric acid, with evolution of chlorine, which become yellow-brown on adding water, a behavior characteristic of solutions containing considerable quantities of cobalt with iron, and by which these wads may generally be distinguished from earthy manganese.

As to the nature of the unaltered mineral from which these cobaltiferous gossans are derived by oxidation, it is possible to form a very probable hypothesis. The absence of arsenic, not only from these, but from many other minerals that I have examined from this region, leads to the conclusion that this mineral must be a *sulphide*, and not an *arsenite* of cobalt and nickel; and the resemblance of these substances to the cobalt and nickel ore from *Mine la Motte*, in Missouri, which is also a product of oxidation, is presumptive evidence that the original mineral may be identical with or at least similar to the one existing there, which was found by Dr. Genth to be *siegenite*. * * The fact that the decomposed substance contains but 13 per cent. of oxide of cobalt and nickel is not against this hypothesis, for in the oxidation of such a mixture of sulphides, the produced sulphates of cobalt and nickel, particularly the latter, would be in great measure washed away, whilst the iron and manganese, passing to a higher state of oxidation, would remain behind in insoluble forms. I cannot, therefore, resist the belief that these veins, when opened to a depth below the line of oxidation, will be found to contain either siegenite or some species very much like it. * * * * * *

Civil and Mechanical Engineering.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from Vol. LIX., page 400.)

Sawing Machinery.

Having, in the preceding number, spoken of sawing machines in general, as applied to timber cutting, and the principles involved in their operation, we will now consider more in detail some of the machines in modern use. We illustrate, in Figs. 1 and 2, a roller gang mill, from the designs and manufactory of Messrs. Allen, Ransome & Co., of London. The cut (1) shows true elevations of front and side view, a plan of illustrating machinery which has many advantages over perspective views in conveying a correct idea of proportions and dimensions.

The machine, as will be seen, is so designed as to have all of its parts above the floor-line, an arrangement that often becomes necessary when pits cannot be made for the crank-shaft. In the low, swampy lands of Central and South America, for instance, the cost of a cemented wheel-pit would be very great, particularly when stone cannot be procured; but, with this arrangement of the machine, a good foundation of piles or timber is all that is needed.

The machines, as manufactured by this firm, are from 3 to 12 tons in weight, and adapted to logs from 12 to 36 inches in diameter. The ends of the logs are carried on two trucks, as shown in the side elevation, provided with lateral motion to accommodate curvature in long timber. The "sash" is constructed of wrought iron, and all the parts so fitted and proportioned as to stand the rough duty of forest sawing in hard timber.

For buildings of two stories, or where the shaft is placed in a pit and the connecting-rod attached to the bottom of the sash, these mills are often "double," feeding through two logs at one time, with a continuous feed of from 20 to 40 inches per minute. Their performance is remarkable both as to the character of the work and the speed. A firm in Sweden operating the double mills of Messrs. Allen, Ransome & Co., with one of them manufactured

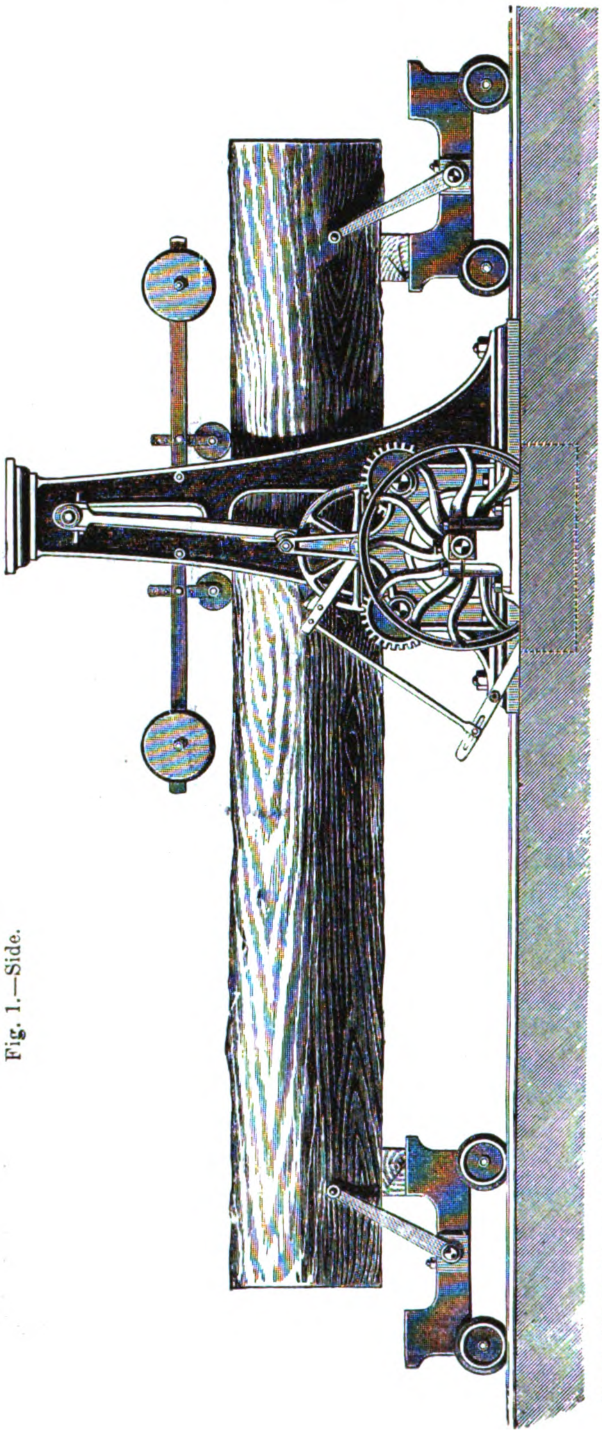


Fig. 1.—Side.

250 logs into lumber in 24 hours.

Plate 1 is a front elevation of a combined log and deal mill as manufactured by the same firm, arranged to cut a single log, with continuous roller feed, or by a little change converted into a deal-frame, or, as we in this country would call it, a re-sawing machine for reducing two deals or flitches at once to lumber of thinner dimensions. This machine being intended more especially for fir or pine wood, is not quite so heavy in its proportions as the regular log mill before referred to. The feed is arranged at from 20 to 40 inches per minute. Under the several modifi-

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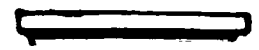
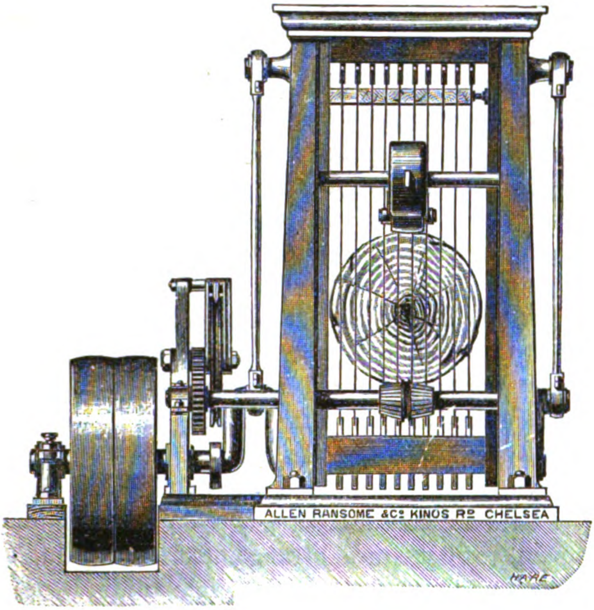


Fig. 1.—Side.

cations manufactured it weighs from 5 to 12 tons, and receives logs from 15 inches to 36 inches in diameter. The speed is from 120 to 180 revolutions per minute, which, with the speed given indicates

Fig. 2.—Front.



the capacity of the mill. The cords and weights give pressure for the vertical feeding rolls for deal sawing. The feed is intermittent, and arranged with the frictional griping dogs to avoid noise.

Messrs. Camel, Owen & Co., Ship Builders, of Detroit, Michigan, after numerous failures in attempting to cut ship stuff with our sawing machinery as constructed for ordinary lumbering purposes, imported a machine of this class from McDowell & Son, of Glasgow, Scotland, of 13 tons weight. The writer saw it in operation after two years' duty, up to which time Messrs. Camel, Owen & Co. stated that not a single dollar had been expended for repairs. A sufficient number of saws are used to reduce the whole log at one operation, following approximately the grain of the timber, which is important for ship lumber, and a function not yet, as we are aware, introduced by any manufacturer of saw mills in this country.

The distinguishing feature of the mills illustrated, considered

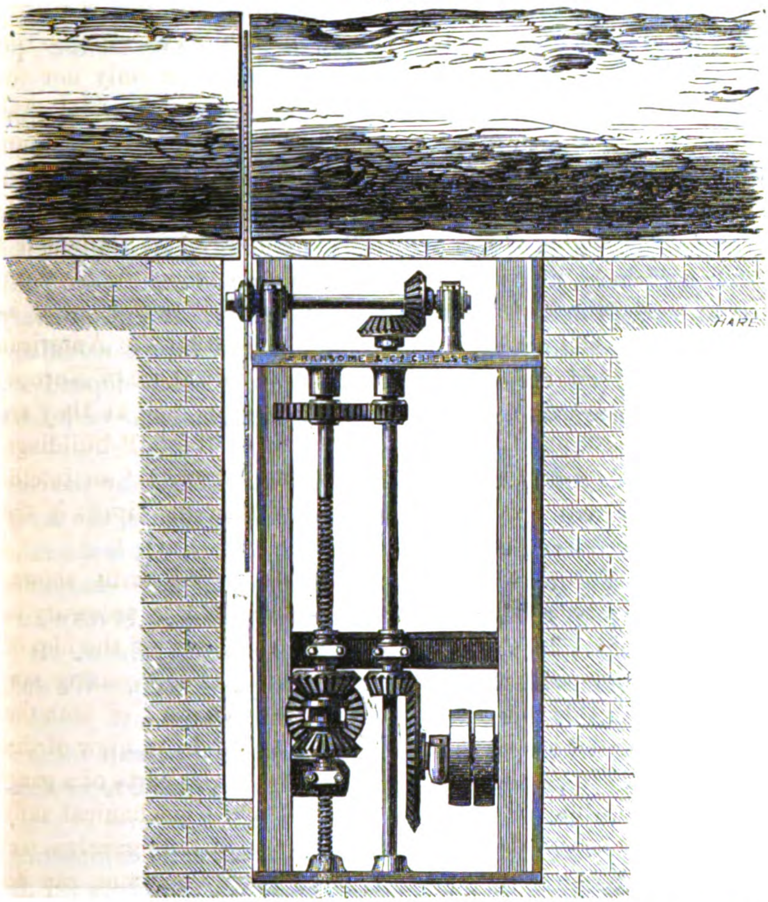
with reference to those of our own country, is in their being self-contained machines, framed up in metal, and without any reference to attachments to the buildings in which they stand. The cheapness of wood here, and the cheapness of iron in England and on the Continent, is generally accepted as the reason for this disparity in the designs for sawing machinery; but while this may be one among other reasons, it cannot be considered as the only nor the most important one. In England, the highest mechanical skill and engineering knowledge is brought to bear on the manufacture of sawing machinery. They have the advantage of a long experience and an extensive market for their productions. The low rate of interest on money makes the amount invested in a machine a secondary matter, if thereby greater durability or better performances is secured. Viewed with reference to their performance, as compared with their cost, there is no doubt but what the American "gang mill," for logs, will compare favorably with those of Europe; but there being no standard for their construction, and as they are not self-contained, but built into the framing of the mill buildings, it will be impossible to present illustrations conveying an intelligible idea of their construction, at least within the limits of the *Journal.*

The compact, self-contained arrangement of the mills shown, aside from the question of mechanical adaptation, is necessary in making machinery for foreign markets. Conceive of the idea of sending the disintegrated parts of an American reciprocating saw mill to be assembled and arranged by those ignorant of both the construction and operation of machines of all kinds, in view of the fact that the proper arrangement and mounting the parts of a gang or sash saw mill, in this country, involves more mechanical skill and knowledge than the construction of the parts themselves (an art which we term, in this country, millwrighting), men can be found qualified for this work in any section of the United States as well as for the care and operation of the mills: hence our peculiar system of building them.

In case of disarrangement or breakage of any part, we have have shops in nearly every town and village where repairs can be made or any part duplicated, whether of wrought or cast iron, brass or wood; but in Russia, Turkey and India, where totally different conditions exist, it is obvious that our system of constructing lumber mills would fail.

Fig. 3 shows a true side elevation of a log cross-cutting machine, as constructed by Messrs. Allen, Ransome & Co., of London. Two sizes are made of 3 and 4 tons weight, including details, framing

Fig. 3.



and supports. The machine as represented, is placed in a pit at the end of the mill where the logs enter, and being entirely below the floor-level, is out of the way when not in use. It corresponds to what is known as the butting saw in our mills, and is a necessary adjunct in log mills. Trees, when felled with axe are, of course, bevelled off at the butt by the kerf; this butt, when its weight is not an objection in transporting the logs, can be cut off more perfectly and more cheaply by power at the mill than by hand in the forest.

(To be continued.)

COMPARATIVE ECONOMY OF IRON AND STEEL RAILS.

By Ashbel Welch, C. E.

The unit of value used in the following investigation is that of a mile of rails; without regard to how it is made up of tons per mile or rate per ton.

We shall have occasion to speak of value in each of its three ordinary senses, always distinguishing which; otherwise our results will be conflicting. The greatest difficulty met with in the study of our subject, arose from the ambiguity of this term.

The *intrinsic value* of a mile of rails is measured by their capacity for usefulness, and that, mainly by their endurance; and that depends on their material, size, form and quality. It does not vary, and it does not distinguish between present and future usefulness.

The *exchangeable value* is measured by price, which depends not only on intrinsic value, but on many other things, and varies frequently.

The *economic value*, as we shall call it, is measured by the combined capacity and opportunity for usefulness, that is, the actual usefulness where used, under actual circumstances. It is the value to the user. Future usefulness and future expenses chargeable against it, must be reduced to present equivalents. It may vary by variation of traffic, that is of opportunity for usefulness. It is this kind of value with which we have principally to do. We shall use the word in this sense when not otherwise stated.

An engineer who speaks of value, is likely to mean *intrinsic* value; a merchant, *exchangeable;* a shareholder, or his representative, *economic* value.

Those who have ruined their employers by splendid engineering, have done so because they neglected the distinction between the intrinsic and economic values of their work. They have created capacity for usefulness entirely disproportionate to the opportunity for usefulness.

That is the best engineering which accomplishes the purpose most economically. The present enquiry is therefore a proper one for engineers. They err who look only at intrinsic values.

A heavy steel rail, laid in a car shed, has four or five times the intrinsic and exchangeable value of a light iron rail; but for use in that place, scarcely any more economic value.

These values, though widely different, are related. Economic

value depends partly on intrinsic, and so in that direction is indirectly related to exchangeable value, which is also partly dependent on intrinsic. Economic value is directly affected by future prices, which control the cost of renewal or replacement.

We shall speak of the duration of rails without distinguishing between the effects of endurance, amount of traffic, weight of machinery, or speed of trains. These and other things must be carefully considered in determining the data to be used in the calculations.

Except when otherwise stated, traffic, and therefore values as well as prices, will be considered constant.

The economic value of a short-lived superstructure is most affected by endurance; that of a long-lived one, by interest, on which depends the present values of future quantities. If one mile of rails will last one month, and another ten months, on the same road, and the cost of renewal in each case is equivalent to a total loss of the rails, then, for that road, the latter is worth nearly ten times as much as the former. But if one will last ten years, till money doubles, and the other ten times as long, then the latter, for that road, is not worth quite twice as much as the former.

The present value of the second decade of the life time of a rail, is only half that of the first; of the third decade, only a quarter, and of the tenth, less than a five hundredth part of that of the first.

On a road where iron rails will last six or eight years, it is therefore of comparatively little consequence whether steel will last half a dozen, or a dozen times as long.

As the value of the rails for a particular road depends not only on their endurance, but also on the amount of traffic they are to carry in some specified time, that is, on their opportunity for usefulness, it is important to estimate correctly, not only what they are able to carry, but what there will be for them to carry. An error in estimate of traffic on any road, is also an error in estimate of value of rails for that road.

It greatly facilitates the comparison of the values of rails, or other things of different duration, with constant traffic or constant tendency to deterioration, to compare both with those that under the same circumstances will last forever. The relations of the destructibles to the indestructible are simpler than their relations to each other.

The practical question has generally been, and often continues to be, not, which is most economical for perpetuation, but whether

iron should be used first, while traffic is light and money scarce, and steel dear, and then, when worn out, be replaced by steel.

Let I be the value of a mile of iron, or other inferior or light rails for perpetuation, and J for replacement by some superior rails, that in the place to be provided for will last through the time T; S the value of steel, steel headed, or some superior or heavier rails that will last a longer time T′; and V the value of a mile that under the same circumstances will last forever.

Let L and L′ be the losses at the times T and T′ respectively for renewals; including rerolling, transportation, relaying, interruptions, repairs and interest thereon up to the time of renewal, risks and all other expenses and inconveniences; and *d* the decrease in economic value of the superior rails at the time when the inferior are worn out.

Let r be the rate of interest for the unit of time; $a = (1 + r)^{T} - 1$ the rate of accumulated interest for the time T, and a' for the time T′; and a'' the rate for a time equal to T′ — T.

Then supposing traffic and cost of renewals constant,

$$a\,V = a\,I + L \text{ and } a'\,V = a'\,S + L' \quad \text{Hence}$$

$$\text{(I.)} \qquad V = I + \frac{L}{a} = S + \frac{L'}{a'},$$

$$\text{(II.)} \qquad I = V - \frac{L}{a} = S + \frac{L'}{a'} - \frac{L}{a}$$

$$\text{(III.)} \qquad S = V - \frac{L'}{a'} = I + \frac{L}{a} - \frac{L'}{a'}$$

The whole current cost for each unit of time $= r\,V$; which consists of two parts, the interest $r\,I$ or $r\,S$, which is paid as it accrues, and the economic depreciation $\frac{r\,L}{a}$ or $\frac{r\,L'}{a'}$ the payment of which, with the interest on it, is postponed till the rails are worn out.

The whole current cost that accrues during the lifetime of the rails is, $a\,V$ or $a'\,V$, consisting of interest $a\,I$ or $a'\,S$, and losses on renewal L or L′.

The present value of the loss L is $\frac{L}{a+1}$:

(IV.) The present value of L and its successors forever $= \frac{L}{a}$

The present value of the accumulated interest and loss at the time T is,

(V.) $\frac{a\,\text{I} + \text{L}}{a + 1}$, which is sometimes a convenient measure of the expensiveness of the rail.

The *physical* depreciation and consequent decrease in intrinsic value of a steel rail, when the iron rail is worn out, is,

(VI.) $\frac{\text{T}\,\text{L}'}{\text{T}'}$; but the *economic* depreciation and decrease in economic value, d is

(VII.) $d = \frac{a\,\text{L}'}{a'} = a\,\text{V} - a\,\text{S}$, supposing traffic constant.

If an iron rail will last till money doubles, and a steel rail four times as long, the physical depreciation of the steel, when the iron is worn out, is one-fourth of the cost of renewal; but the economic depreciation, the decrease in value to the owner, is only one-fifteenth of that cost. For, supposing the present value of the first decade to be 8; that of the second will be 4; of the third 2; and of the fourth 1; and the sum of present values of the first three decades will be 14; that of all four decades only 15; so that the value to the owner, is reduced only one-fifteenth by a reduction of one-fourth of the duration of the rail.

If the loss on renewal is a percentage m on I or m' on S, then

$$\text{(VIII.)}\quad \text{I} = \frac{a\,\text{V}}{a + m} = \frac{a\,\text{S}\,(a' + m')}{a'\,(a + m)} = \frac{a\,\text{S}}{a + m} + \frac{a\,m'\,\text{S}}{a'\,(a + m)}$$

Steel partly worn, that will still last just as long as new iron, is not necessarily worth the same as new iron, because worn out steel is probably worth more than worn out iron. So partly worn heavy rails that will last just as long as light new rails are worth more, because the worn out heavy are worth more than the worn out light rails.

The value of the partly worn steel is $\text{S} - d$, and the current cost for their residuary lifetime is,

(IX.) $a''\,\text{S} + \text{L}' - (a'' + 1)\,d$.

If the price p of the iron is not the same as its economic value I, as compared with steel, the advantage or disadvantage of the iron is of course the difference between p and I; and the current cost for the unit of time becomes $r\,p + \frac{r\,\text{L}}{a}$.

But p in that case cannot be substituted for I in the foregoing equations.

Any future changes in the prices of rails to be perpetuated are most conveniently provided for by increasing or decreasing the values of L and L′.

In comparing steel with iron to be replaced by steel, it is necessary to take the changes in price into the calculation. Let q be the expected price of steel at the time of replacement; and let b = balance of value of the worn out iron rails over the cost of removal, and of laying down the steel to replace them, together with all the attendant risks, inconveniences and expenses. Then to make iron for replacement equally advantageous with steel

(X.) $\text{J} = \text{S} + \dfrac{b + d - q}{a + 1}$. Or, if the price of steel is constant,

$$\text{J} = \frac{a\,\text{V} + b}{a + 1} = \frac{a\,\text{S} + b + d}{a + 1}$$

If the traffic is expected to vary, the time must be cut up into periods coextensive with the lifetimes of the iron rails, throughout any one of which the traffic must be considered uniform, and the depreciations and values at the end of each period found by the preceding rules.

When the traffic varies, the depreciation in value of the steel has no relation to interest past, but only to future interest. It must be found by comparing the remaining duration of the partly worn steel under the expected circumstances, with that of new steel. Then a'' being the rate of accrued interest for a time equal to the difference between the residuary lifetime of the partly worn steel and new steel, and that of new steel put down at the same time being a', the depreciation of the partly worn steel is

(XI.) $$d = \frac{\text{L}'}{1 + a''} - \frac{a''\,\text{L}'}{a'\,(1 + a'')}.$$

The loss from the value of new steel on renewal being L′, that from the value of partly worn steel will be $\text{L}' - d$.

When the traffic varies, the value of V varies of course with each change.

Simple and obvious when stated, as the foregoing views and rules are, they were arrived at through calculations much more complex, and sometimes apparently conflicting.

These rules, and the tables deduced from them, do not aid in determining data, nor in any degree supersede experience and sound judgment. But as there are two chances of error, one of judgment and another of calculation, convenient formulæ reduce such chances to one; or at least, diminish the second.

In the following tables some illustrations of the applications of the formulæ, some results and some numbers useful in finding other results are given.

TABLE 1.

Quantities frequently represented in the foregoing formulæ. Steel supposed to last eight times as long as Iron. Traffic constant.						Quantities frequently represented in the foregoing formulæ. Steel supposed to last eight times as long as Iron. Traffic constant.					
T Dura'n of Iron Rails.	a or a' Rate of accrued interest.	$L = \frac{4000}{a}$ Present value of loss on renewals.	$L' = \frac{5000}{a}$ Present value of loss on renewals.	T' Corresponding dura'n of Steel Rails.	$d = \frac{a L'}{a'}$ Depreciation of Steel.	T Dura'n of Iron Rails.	a or a' Rate of accrued interest.	$L = \frac{4000}{a}$ Present value of loss on renewals.	$L' = \frac{5000}{a'}$ Present value of loss on renewals.	T' Corresponding dura'n of Steel Rails.	$d = \frac{a L'}{a'}$ Depreciation of Steel.
1	0·071+	56,330	70,425	8	484	54	40·07	100	125		
2	0·147+	27,210	34,012	16	366	56	46·13	87	109		
3	0·229+	17,470	21,837	24	271	60	61.06	66	82		
4	0·317—	12,620	15,775	32	197	64	80·72	50	62		
5	0·411+	9,732	12,165	40	140	66	92·77	43	54		
6	0·511+	7,828	9,785	48	98	70	122·5	33	41		
7	0·619—	6,462	8,077	56	67	72	140·7	28	35		
8	0·734	5,450	6,812	64	45	78	213·1	19	24		
9	0·858	4,662	5,827	72	30	80	244·7	16	20		
10	0 990	4,041	5,051	80	20	88	425·0	9	11		
11	1·132	3,534	4,417	88	12	90	487·9	8	10		
12	1·283	3,118	3,897	96	8	96	737·7	5	6		
14	1·620	2,469	3,080			100	971·8	4	5		
16	2·007	1,993	2,491								
18	2·450	1,633	2,041								
20	2·959	1,389	1,736								
24	4·214	949	1,186								
30	6.878	581	726								
32	8·040	497	621								
36	10·90	367	459								
40	14·68	272	340								
42	16·99	235	294								
48	26·18	153	191								
50	30·19	132	165								

TABLE 2.

Values of one mile of Rails to be equally economical.

L assumed at 4000, and
L′ " " 5000.

T Dura'n of Iron.	I = value of Iron for perpetuation. $I = \frac{V-L}{a}$	J = value of Iron for replacement. $b = 2500$ $J = \frac{av+b}{a+1}$	T′ Dura'n of Steel.	S Value of Steel.	V = value of Indestructible Rails.
1	—39,528	3449	8	10,000	16,812
2	—14,719	3780	16	10,000	12,491
3	— 6,284	4126	24	10,000	11,186
4	— 1,999	4462	32	10,000	10,621
5	.608	4784	40	10,000	10,340
6	2,368	5101	48	10,000	10,191
7	3,647	5409	56	10,000	10,109
8	4,612	5701	64	10,000	10,062
9	5,373	5980	72	10,000	10,035
10	5,979	6241	80	10,000	10,020
11	6,477	6488	88	10,000	10,011
12	6,888	6718	96	10,000	10,006

TABLE 3.

Annual current cost of one mile of rails. Rails of equal economy. Traffic constant.

L = 4000. L′ = 5000.

T	T′	r V	r I	$\frac{r\,L}{a}$	r S	$\frac{r\,L'}{a'}$
1	8	1194	....	....	710	484
2	16	887	....	....	710	177
3	24	794	....	....	710	84
4	32	754	....	....	710	44
5	40	734	43	691	710	24
6	48	724	168	556	710	14
7	56	718	259	459	710	8
8	64	714	327	387	710	4
9	72	712	382	330	710	2
10	80	711	425	286	710	1
11	88	710	460	250	710	0
12	96	710	489	221	710	0

TABLE 4.

Comparative economy of Steel Rails and Iron Rails for replacement, taking into account changes in price from 1867 to 1870.

J, value of iron; S, value of steel; q, price of steel when iron replaced; b, value of old rails over expenses; d, depreciation of steel; a, accrued interest; p, price of iron.

$$J = S + \frac{d + b - q}{a + 1}$$

In 1867, steel cost	$15,000	Iron,	$8,500
" 1868, " "	14,000	" $7,600, $b =$	3,500
" 1869, " "	12,000	" 7,600, $b =$	3,500
" 1870, " "	10,000	" 7,400, $b =$	3,000
After 1870, " "	9,000	$b =$	2,500

1867			1869		
Dura'n of Iron.	J = value of iron for replacement.	p — J = Advantage of steel.	Dura'n of Iron.	J = value of Iron for replacement.	p — J = Advantage of Steel.
1	5650	2850	1	5917	1683
2	7912	588	2	6655	945
3	9526	—1026	3	6938	667
4	10218	—1718	4	7218	387
5	10491	—1991	5	7491	109
6	10763	—2263	6	7763	— 163
8	11277	—2777	8	8277	— 677
10	11743	—3243	10	8748	—1143
12	12157	—3657	12	9157	—1557
1868			**1870**		
1	6517	1083	1	4384	3016
2	8219	— 619	2	4655	2745
3	8938	—1338	3	4983	2467
4	9213	—1613	4	5213	2187
5	9491	—1891	5	5491	1909
6	9763	—2163	6	5763	1637
8	10277	—2677	8	6277	1123
10	10743	—3143	10	6748	657
12	11157	—3557	12	7157	243

The values of iron for replacement, in the foregoing table, are different from those in Table 2, Col. 3, for the reason that in the latter the price of steel is considered constant, while in this table it is constantly declining.

In these tables the losses preceding and attendant on renewal of iron rails, are assumed at $4000. With light rails and not very heavy traffic this is ample to cover all inconveniences. With heavy rails and frequent trains to be interrupted, the cost and inconveni-

ence will be much more. The loss on renewal of steel is assumed to be $5000. That will depend partly on the cost of new steel, and that on the import duties, which are not yet settled. We have assumed that it will be $9000 per mile, which contemplates an advance in duties sufficient to counterbalance the decline in premium on gold. The value of worn out steel is as yet quite uncertain. These, like all other data, must be ascertained for each case, and corrected on new information.

The percentage of difference between $4000 and any other value of L, will also be the percentage of difference between the numbers in third column of table I., and the numbers deduced from such other value.

It is obvious from inspection of table IV., that iron rails to be replaced by steel have heretofore been found more economical than steel; provided, that those laid in 1867 would last two or three years, those laid in 1868, a year or two, and those laid in 1869 half a dozen years.

But in 1870 it is equally obvious that steel is more economical than iron that will last even ten or a dozen years, if our data for the future are at all correct.

As a good iron rail will last several times as long as a poor one, and there is no standard of quality, it is impossible to say how much longer steel will last than iron. It will last more than twenty times as long as much of the iron laid during the past ten years. In the tables it is assumed to last eight times as long. On most roads, for the reasons already given, this question is of but little importance.

If the cost of renewal or replacement is a fixed sum, then the difference between the values of iron and steel is also a fixed sum; and there should always be the same difference between the prices. If the cost of renewal is a percentage, the values do and the prices should differ by a percentage.

These formulæ may be used in comparing the ultimate economy of bridges, buildings, vessels, and other things of different cost and durability used for the same purposes.

If single headed rails cost $7500 and last five years, and double headed, with the chairs they set on, $10,000, and last twice as long, and if the expenses of renewals are $4000 and $5000 respectively, then $p = 7500$. $S = 10000$. $L = 4000$. $L' = 5000$. $a = 0{\cdot}411$ and

$a' = 0{\cdot}99$ and (neglecting the cost of reversal and constant cost of wedging the double headed).

$$\text{I} = \text{S} + \frac{\text{L}'}{a'} - \frac{\text{L}}{a} = 10000 + \frac{5000}{0{\cdot}99} - \frac{4000}{0{\cdot}411} = 10000 + 5051 - 9732 = 5319$$

So that the double headed has the advantage of $p - \text{I} = 7500 - 5319 = 2181$ over the single headed for perpetuation.

Suppose that a wooden bridge will cost $10,000, and last sixteen years; and that the repairs, insurance, watching, and all expenses on it, with the interest on those expenses up to the time of renewal, and the cost of removal and the inconveniences, all together, amount to $5000, over the value of the old materials; and that a permanent bridge can then be built at the same cost as at first. Then $\text{I} = 10000$. $\text{L} = 10000 + 5000 = 15000$, and $a = 2$. Substituting these in the equation $\text{V} = \text{I} + \frac{\text{L}}{a}$, we have $10000 + \frac{15000}{2} = 17500$, equal to the value of a bridge that will last forever.

When the business is very heavy, the inconvenience of renewals, and the risks from fire or accident of temporary structures, are of course controlling considerations. If the interruption caused by the burning of the wooden bridge would involve a loss of $50,000, and the annual chance of burning is one in a hundred, then the annual risk of $500 capitalized, adds $7042 to the difference between the values, making that of the indestructible bridge $24,542.

As traffic generally increases faster than is expected, (though profits do not) steel rails and permanent structures become more advantageous than the calculations. They also have the advantage of safely allowing increased weights and speeds, which may become important.

On the other hand, where safety is not involved, and interruption would not cause serious loss, and especially where, (as happens so often in this country,) changes of route or plan are liable to be made, and where calculation makes the ultimate economy nearly equal, it is best to adopt the cheaper rail or structure. This is especially the case in station buildings and shops. Dead capital and outlay for a future generation better able to help itself than we are to help it, are thus avoided.

Our calculations are made on interest at 7 per cent., compounded semi-annually. Few railroad companies borrow at lower rates, many at much higher. Of course the calculations for each road must be based on the actual rate.

The writer having had much occasion to deal with these questions, has arranged the foregoing rules and tables for his own convenience. He presents them for publication, hoping they may sometimes abridge the labor of others who have to deal with the same questions.

Comparisons such as that of the ultimate economy of the wooden and stone bridges are often judged of in this country, though perhaps not often formally made. But an eminent European Engineer told the writer, some years ago, that the idea of such a comparison was entirely new to him.

Printers' Copying Ink.—The want of a method by which the press-copying of printing could be as easily and efficiently accomplished as that of written matter has been so universally felt, that the advent of any process claiming to perform the work will be looked upon with interest by all who make constant use of printed blanks, of which they wish to retain a press copy.

Mr. McIlvain's Printers' Copying Ink, which, as the name indicates, is intended to accomplish this result, consists of a number of soluble colors, prepared to be used in printing, by a process upon which he has obtained a patent. If we may judge from press copies in our possession, the process of Mr. McIlvain leaves little or nothing more to be desired in this direction. The colors are in some variety (black, purple, red, green and blue), and with each of them a satisfactory transfer can be made.

The fact that the copy is a complete duplicate of the original, in printed as well as in written matter, infinitely increases the value of the former, and is sufficient to set aside any doubts which might otherwise arise concerning the authenticity or exactness of the transaction involved.

We understand that Mr. McIlvain's invention has already been considerably and favorably introduced. The Pennsylvania Railroad Company, The Empire Transportation Company, M. Baird, and others having adopted it to print their forms, &c.

Lime Lights in the Caisson of the East River Bridge.—We learn from Mr. C. H. Stoddard, Secretary of the New York Oxygen Gas Manufacturing Co., that they have contracted to furnish oxygen for six lime lights to be burned day and night in the six compartments of the huge caisson whose structure and launching we described on p. 223 of our last volume.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from Vol. LIX., page 327.)

Vulcanized Rubber Belts.

We are indebted to Mr. D. P. Dieterich, Esq., of 308 Chestnut Street, this city, Agent for the New York Belting and Packing Company, the oldest and largest manufacturing firm in the United States of vulcanized rubber fabrics adapted to mechanical purposes; for the following valuable collection of facts and statements concerning rubber belts.

"This belting is made of heavy Cotton Duck, weighing 2 pounds per yard, woven expressly for the purpose, and is vulcanized between layers of a patent metallic alloy, by which process the stretch is entirely taken out, the surface made perfectly smooth, and the substance thoroughly and evenly vulcanized.

"The superiority of this Belting over the best Leather Belts has been proved by a trial of more than 10 years. It is manufactured by a process peculiar to this Company, by which unusual firmness and solidity are obtained, thereby obviating some objections heretofore urged against india rubber belting made in the old way.

"This, together with the fact that other great improvements have been made in its quality warrants us in asserting that it is superior to leather, or anything else, for all open belts, particularly heavy or main belts, for the following reasons:—It has a perfectly smooth and even surface. It seldom and scarcely ever requires tightening more than once. It will always run straight and with perfect bearing on the pulleys, by which we believe that a power of 20 per cent. is gained over the best leather belts. It will stand heat of 300° Fahr. without being affected, and the severest cold will not stiffen it or diminish its pliability. It is much stronger than leather and far more durable. It can constantly be run in wet places or exposed to the weather without injury.

"From information which we have personally collected on the subject of Vulcanized India-rubber belting, it appears to us that this material is yet designed to effect an economic revolution in driving machinery.

"In the extensive establishment of Burr & Co., Cliff Street, N. Y., where the manufacture of hat bodies is carried on, and where an

immense amount of belting is used, it has taken the place of leather in nearly all work. We instance this case because the machinery in this manufactory is such as to afford a signal test of the quality of belting. One long india-rubber belt, 8 ply and 36 inches wide, is employed to transmit the power from a fly-wheel of two horizontal steam engines of 100 horse-power each.

"The fan-blowers of the 'forming machines,' and those for teasing and cleansing the fur are driven at the high velocities of from 3,000 to 3,500 revolutions per minute. This speed wore out the best leather belts faster than those of india-rubber which have supplanted them.

"India-rubber belting has been for some time used for driving the presses on which the *Scientific American* is printed, and has proved superior in every respect to the leather belts previously employed. It also possesses the qualities of running unaffected under exposure to water, to the open air, and even to a temperature above the boiling point.

"A 5-ply india rubber belt, 12 inches wide, as now manufactured is considered equal to a double leather belt of the same width, and can be furnished at $\frac{104}{220}$ of the price of the latter.

"The new variety of india-rubber belting to which we have referred is manufactured by the New York Belting and Packing Company at Newtown, Conn.

"The cotton duck which gives the peculiar uniform and non-elastic character to such material is woven especially for this purpose, with the warp much stronger than the filling, and cut by machinery into strips of a perfectly regular width. Single strips of this duck will bear a tensile strain of 200 pounds to the inch of width."—*Sci. Amer.*

To the above we add the following valuable testimonials in regard to the practical workings of the india-rubber belt.

D. P. DIETERICH, ESQ., Agent,

Goodyear Rubber Company, Philadelphia.

Dear Sir:—In reply to your inquiry as to the present condition of the main driving belt at our mill, purchased of you in July, 1856, a few brief details respecting the same will, no doubt prove acceptable as expressing our entire satisfaction in every respect.

Passing over a 14-foot belt wheel to a 47-inch receiving pulley on a "line shaft" of great weight, and controlling the entire work

of the "mill," it has in no case failed to accomplish every requirement.

The belt is perfectly regular, bright and flexible, neither frayed on the edges nor strained in any way. In short, we are most confident that it is in as good condition as when we first received it.

Most truly yours,

Philadelphia, June 13th, 1866. J. EISENBREY & SON.

In answer to your inquiry as to whether the 24-inch 6-ply main belt, which we purchased from you has given us satisfaction.

It affords us pleasure to say that it has given us entire satisfaction in every way. We have now had it in constant use for over two years, and it appears to be in as good condition now as the first day we used it, and any person wishing to purchase one, and would like to see ours, can do so by calling at our place of business.

Respectfully yours, &c.,

DR. D. JAYNE & SON,

Philadelphia, August 21st, 1866. 242 Chestnut Street.

We have in use at our works, ten or twelve rubber belts, particularly a twenty-four inch "main belt," which has been running constantly for the last six years, and it affords us great pleasure to say that all of them give entire satisfaction.

Very respectfully yours,

REANEY, SON & CO.

Penn'a. Iron Works, Chester, Pa.,
December 13th, 1866.

It affords us great pleasure to state that during the past twelve years, in which time we have been using your Rubber Beltings at our Locust Run Colliery at Ashland, Pa., and also at our Mammoth Colliery near St. Clair, Pa. We have found them admirable in quality and fitness for the purpose designed.

We have had the Goodyear Beltings in use constantly and speaking understandingly of their merits, we can only add that all parties in need of a first class article will do well to purchase of your well-known house and thereby gain entire satisfaction.

Very truly, yours, &c.,

J. G. & G. S. REPPLIER.

Philadelphia, January 1st, 1867.

Experiments with Belting.

"The comparative adhesion of vulcanized gum and leather belts to the surfaces of pulleys is a question of great interest to manufacturers, and in order to satisfactorily decide it, Mr. J. H. Cheever, of the New York Belting and Packing Co., made a series of experiments, the results of which are here given:—

"The apparatus consisted of three equal size iron pulleys, with faces turned in the usual way and secured to a horizontal shaft also fixed. One of these pulleys was used without covering, one was covered with leather, and one with vulcanized gum.

"In the first set of experiments a leather belt was used of good quality, 3 inches wide and 7 feet long, with 32 pounds weight attached to each end, and the belt thus prepared was laid on the iron face pulley. Additional weights were then attached to one end of the belt until it began to slip, which was in this case found to be 48 pounds.

"When this weighted belt was placed on the leather covered pulley it required a weight of 64 pounds to slip it, and when on the vulcanized gum covered pulley it required 128 pounds to slip it.

"In the second set of experiments, a 3-ply vulcanized gum belt of the same width, length and thickness was used, and to each end was attached the same weight as in the other case.

"To cause this belt to slip on the iron face pulley required 90 pounds additional weight, on the leather covered pulley 128 pounds, and on the vulcanized gum covered pulley 183 pounds.

"In the third set of experiments, the shaft with all the pulleys secured thereto, was permitted to turn freely in its bearings. One end of the belt was fastened to the frame work of the apparatus, and to the other end was attached a weight of 32 pounds as before.

"A rope was wound several times around one of the pulleys, with one end made fast to the rim, and the other allowed to hang freely downward; to this end weights were attached sufficient to produce rotation of the shaft.

"The results were the same, requiring in effect the same amount of weight on the end of the rope to rotate the pulleys under the belt as it did on one end of the belt to slip the belt over the pulleys." *Sci. Amer.*, Mar., 1859, p. 216.

How to use Vulcanized Rubber Machine Belting.

"Belts should be cut $\frac{3}{16}$-inch shorter for every foot of length

required. After running, say, for three weeks, take up the slack and they will never again require shortening.

"To fasten the ends of narrow belts, make two rows of holes in each, butt the ends together and unite by strips of lacing leather in the usual way with leather belts.

"To secure the ends of wide belts, lap the joint evenly on the outside with a piece of square gum or leather, equal in width to the belt, and rivet, sew or lace the same firmly to each end of the belt.

"If belts should slip from dust or other causes, they should be slightly moistened on the pulley side with boiled linseed oil, making several applications if necessary. *Animal oils must never be used*, and belts should be protected, while running, from contact with such oils.

Should the rubber, from long use, or other cause, be worn from the surface of the belt, give it a coat or two of lead paint, containing sufficient *Japan* to dry it quickly.

"For belts which are shifted, put rolls on the shifter bars with axes inclined towards each other at top and bottom, according to circumstances, which has the effect to press the faces of the belts and relieve the edges from wear. By this plan belts are more easily shifted than by the usual method, and the liability to injure the edges entirely prevented. Use large headed bolts or rivets for securing elevator buckets."

General Statements.

"The more nearly *horizontal* a belt can be applied, the better will the weight of the belt produce a sufficient and uniform friction; and a long belt is better than a short one, inasmuch as the *weight* and "*sag*," and consequently the friction, are greater.

"To avoid kinks and crooks in the belts, the ends where joined should be cut *exactly* square across the centre line of the belt.

"The pulleys should be perfectly smooth, and the shafts carrying the pulleys perfectly "*in line*," parallel to each other, and in the same plane.

"Leonard, in his '*Mechanical Principia*,' assumes the ordinary velocity of belts to be 25 to 30 feet per second, and gives a table which may be fully represented by the following:—

$$\text{H P} = \frac{w\,d}{3{\cdot}6},$$

$$w = \frac{3{\cdot}6\ \text{H P}}{d},$$

In which HP = horse-power transmitted.
w = width of belt in inches.
d = diameter of smaller pulley in feet.

"Where belts are not to be exposed to saturation of animal oil, or to frequent abrasion, a combination of rubber and canvas has proved to be fully equal if no superior to leather, and is much cheaper. For large belts rubber is preferable, because the belt, whatever its length or width, is one—not pieces joined by mechanical means or connected temporarily—but solid, and, to all intents and purposes, one continuous fabric.

"For purposes where unusual strength is required—equivalent to double leather—5 and "6-ply" belts are made. Endless belts of any width or length are made to order, costing, in addition to cost of belt, the price of 3 feet of the belt joined, for joining. For belts less than 6 inches wide, the 3-ply is sufficiently strong, unless the work is unusually heavy. Belts wider than 6 inches should not be less than 4-ply, unless the work is light.

"Wherever double leather belts of 14 inches wide and upward have been used, we recommend our 5 and 6-ply belts, and will warrant them to do more work at about *one-half the cost.*

"As an evidence of the capacity of this establishment, we refer to the "Champion" belt, the largest belt ever made of either leather or rubber. It is 4 feet wide, 320 feet long, and weighs 3,600 pounds.

"This company is prepared to make any width of belt not exceeding 50 inches.

"The 3-ply vulcanized gum belt weighs $1\frac{2}{3}$ pounds to the square foot, the 4-ply weighs 2 pounds. Thicknesses as follows: 2-ply $\frac{3}{16}$ inch; 3 ply $\frac{5}{24}$ inch; 4-ply $\frac{5}{16}$ inch; 5-ply $\frac{5}{12}$ inch; 6-ply $\frac{7}{16}$ inch.

(To be continued.)

Artificial Production of Ice.—We notice, in *Cosmos*, an item on the artificial production of ice in India. It has long been known, that during the cool, serene nights of that country, water, in porous vessels, placed in shallow depressions upon straw, might be frozen. The only interest which attaches to the note referred to, is its connection with the name of M. Janssen, who, it is stated, after a series of very ingenious experiments, has arrived at the precise explanation of this phenomenon. His experiments result in a verification of the explanation commonly given it, namely, that it is due principally to nocturnal radiation, aided, however, in no inconsiderable degree by evaporation.

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

By Col. O. W. Childs, C. E.

(Continued from Vol. LIX., page 389.)

The general merits, therefore, of all the routes thus far projected leading from the Lake of Nicaragua to the Pacific, as ascertained in the manner and to the extent above indicated, were, at this stage of the proceeding, duly considered, and the conclusion was arrived at, that the line leading from the lake at the mouth of the River Lajas to the Pacific at Brito, presented more favorable conditions for the construction of the canal than any other: It was therefore determined to survey and carefully to locate a line across upon this route.

The River Lajas has its origin about 10 miles southwesterly from its entrance at the lake, on the eastern slope of the dividing ridge, and after running northwesterly some two miles along the base of the hills, it takes a more northerly direction through comparatively level savannahs, to some extent variegated with conical hills and occasional low ridges, a distance of some 6 or 8 miles to where it bends to the east, and in a distance of 1¾ miles by a good direction it enters the lake.

The River Grande rises on the easterly slope of the same range of hills, and some 2 or 3 miles northwesterly from the sources of the Lajas, and after flowing near the base of the slope some 3 or 4 miles, it bends to the west, and by a narrow and somewhat irregular valley it passes through the ridge, and thence in a more capacious and uniform valley to the Pacific.

The survey was commenced at a point on the bed of the lake 17 feet below the elevation at which its surface stands during ordinary high water, and at which, by the plan, it is to be permanently maintained; to this surface all comparisons of elevation and depression refer. This point is 25 chains from the line of the shore, and directly opposite the entrance of the Lajas: the bottom, which here is a compact gravel, rises by a gradual inclination to the surface of a gravel bar lying upon the line of the shore across the Lajas, and elevated a few feet above the surface of the lake. This bar is alternately formed and removed, or levelled down; the former by the action of the waves during the dry portion of the season, and the latter in the wet season by the force of the current in the Lajas, which opens a channel some 200 feet in width and 4 to 6 feet in depth. The cut to be made through this bar will require protection by a pier constructed on either side, and extended to deep water in the lake. These piers and the cut may be so located as, when completed, will furnish a practicable and safe entrance to the canal.

The river immediately in rear of this bar has a depth of 11 feet

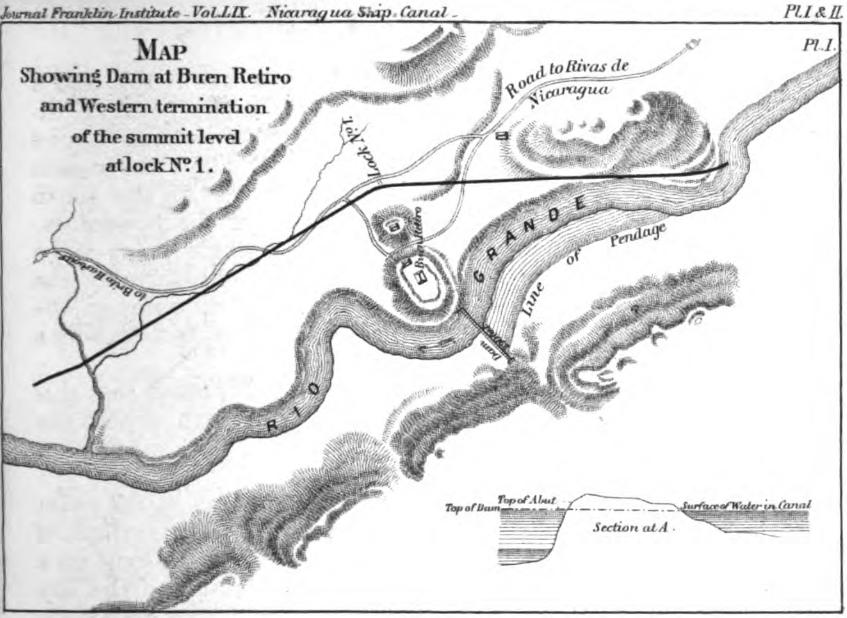
in time of low water: it has an average depth of about $10\frac{1}{2}$, and a width of 100 feet a distance of $1\frac{54}{100}$ miles, to the point of divergence of the line at a bend in the river, a few chains above which the plan contemplates an embankment, by which the stream is to be turned into an artificial channel to be cut on the south side, and leading to the lake a few chains south of the present entrance of the river. With the exception of a single point to be cut through, the line as located occupies the present channel of the river, which will require to be enlarged from deep water in the lake $1\frac{85}{100}$ miles to the bend above referred to. The bottom width of this cut is calculated at 100 feet.

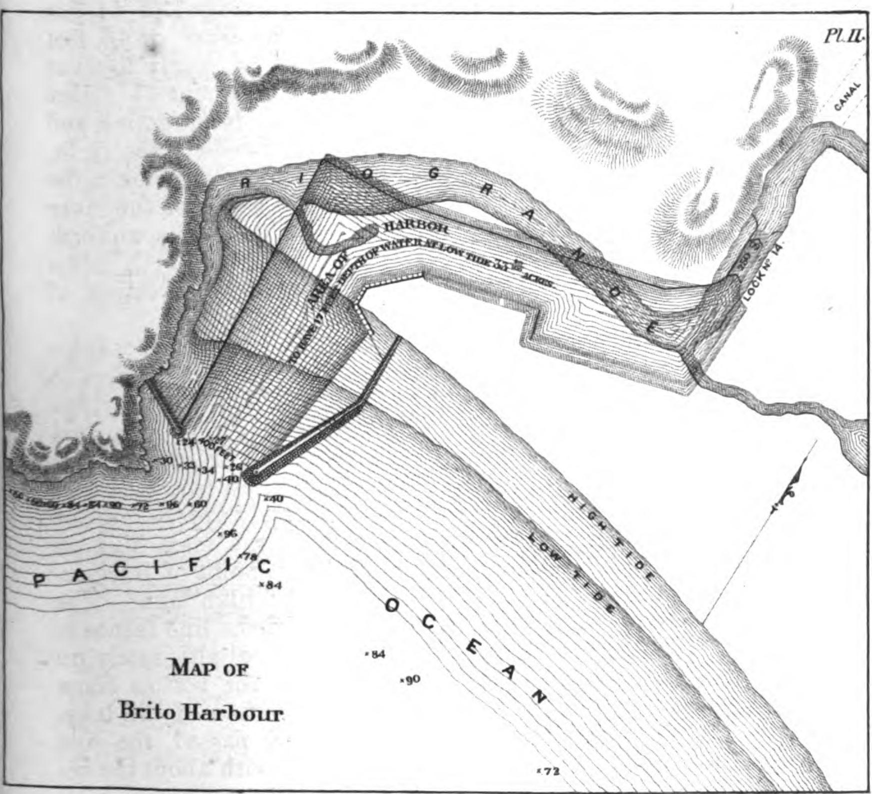
With the stream turned as proposed, it is not supposed that this portion of the canal will be subject to deposits of earth, or that the navigation will in any degree be intercepted by the subsequent formation of bars at its junction with the lake.

The ground surface on the bank of the River Lajas, at the point of its divergence, has an elevation of 5 feet above the surface of high water in the lake; from thence the line, as traced along up a generally broad and very uniform plane in the direction of the Rio Grande, reaches the summit between these streams by a good direction in a distance of $3\frac{75}{100}$ miles, and with an ascent of 41 feet above the bank at the point of divergence at the river, or 46 feet above high lake. The valley at this summit is nearly level at right angles with the line, and has a width of about $1\frac{1}{2}$ miles. Proceeding from the summit with the same general direction and uniformity of surface, the line by an easy curve bends to the right, and crossing the Espinal, a small though permanent brook to be taken into the canal from the north, reaches the banks of the river Grande in the further distance of $1\frac{78}{100}$ miles, with quite a uniform descent from the summit of 26 feet, or at a distance of $7\frac{38}{100}$ miles from 17 feet depth of water in the lake, and with an elevation of 20 feet above its surface.

The stream here approaching the line from the south, takes a more westerly direction, and descending at the rate of $9\frac{82}{100}$ feet to the mile, passes with many sinuosities through the dividing ridge in a valley of little greater width than is necessary for the canal and the deposit of the surplus material excavated from its prism. The channel in which the stream flows is about 70 feet wide and 15 feet deep, and in its serpentine course alternately approaches the bases of gently sloping spurs projecting from the main hills on either side. The bed of the channel at the first point of intersection by the line is 2 feet above the surface of high lake: The stream is here to be received into the canal, and the line thence is located intermediate the valley, leaving the channel alternately on opposite sides a distance of $1\frac{45}{100}$ miles, to where the bottom plane of the channel is depresed 19 feet below the surface of the lake.

The point of excess of cutting having been passed, the line leaves the channel of the creek to the left, and with about the re-





Lith. Jas. McGuigan, Phil^a.

quisite depth of cutting, is traced across a lateral valley over a favorable surface $0\frac{54}{100}$ miles, to where it again enters the channel of the Rio Grande, which from this point, with its bed $28\frac{1}{2}$ feet below the surface of the lake, passes through a narrow opening in another ridge, furnishing for the line a favorable location a distance of 45 chains, where by a slight curve to the right it again leaves the channel of the stream, and enters the head of a ravine of favorable dimensions and elevation, which it pursues a further distance of 12 chains to the lock located at the termination of the summit level, $10\frac{9}{100}$ miles from 17 feet depth of water in the lake. Eight chains below the point of divergence of the line from the creek a dam is to be constructed across the stream, by which its waters are to be raised and maintained at the same elevation as that of the lake. For a more perfect view of the plan at this point, see accompanying map of the western terminus of the summit level.

The quantity of water passing in the Rio Grande during its maximum flow, as calculated from the highest water mark found on the face of its banks and its known width and descent, is 5,670 cubic feet per second. This quantity, on being received into the canal, will, owing to the difference in conditions of flow, pass in somewhat unequal portions into the lake, and over the dam at the west end of the summit level, with a depth on the crest of the dam of $1\frac{65}{100}$ feet, it will move with the same mean velocity in both directions, or about $1\frac{42}{100}$ miles per hour. This stream very seldom rises to the height here assumed as its maximum flow, and the very limited and highly inclined surface of the country drained by it is such that it continues at this height only a few hours. During a large portion of the dry season, the water in that portion occupied by the canal percolates through, and none passes over the gravel bars distributed along its bed. It would be desirable in this, as in all other cases, to avoid streams, however small, not beneficial as feeders to the canal: In the present instance this could not, by reason of the limited space in the valley before described, with propriety be done. With the weir so constructed as to prevent the influx of earthy matter, and the consequent formation of bars, it is believed that the receiving of this stream into the canal under the peculiar circumstances of flow will not be seriously detrimental to the navigation.

Proceeding from the first lock, the line is traced along the centre of the ravine, which gradually widens, and with a uniform and moderately descending surface, again unites with the more immediate valley of the Rio Grande, which here has a northerly direction. The line is thence continued along the easterly side of the creek $1\frac{50}{100}$ miles to the point of extreme northing made by the stream, where it curves to the west, and with a good direction over a highly favorable surface, it reaches the River Tola in a further distance of $1\frac{42}{100}$ miles, a stream considerably less than the River Grande, and which is to be received into the canal from the north.

The River Grande is to be turned by a short cut, in alluvial earth, on its south side, across a projecting point of the flat. The canal also occupies a portion of this point, and with the present channel of the creek forms a somewhat spacious basin, in which the Tola is to be received and discharged on the opposite side of the canal, over a weir to be constructed of such length as will prevent the water of the Tola, in time of floods, from elevating to an injurious extent the surface of this level of the canal.

A towing-path bridge will be required across the channel of the Tola. The line is thence continued along a moderately descending and broad flat, having a general elevation of 18 to 20 feet above the stream $1\frac{84}{100}$ miles to where it crosses a spur branching from a high ridge, forming the westerly bounds of the valley of the Tola. After passing a gap in the spur, involving a cut 33 feet in depth, and 2 chains in length, the line in a further distance of 29 chains again enters the channel of the Rio Grande, which by a short cut is to be turned, and its present channel occupied by the canal 6 chains to opposite the abrupt termination, at the north side of the creek, of another spur of the ridge. Leaving the creek at this point, the line, by an easy curve to the right, is extended westerly through broad interval lands $1\frac{95}{100}$ miles; thence in a southerly direction $\frac{60}{100}$ miles to where it enters the channel of the River Grande, in which it continues a further distance of 17 chains to the location of the lower or lock No. 14, connecting with the lowest tide-water of the Pacific. About 16 chains easterly from this lock the creek, by an embankment, is to be turned into an artificial channel to be cut in earth $\frac{52}{100}$ miles across a low flat to the Pacific, at a point $\frac{62}{100}$ miles southerly from its present termination, and the canal or artificial harbor is to occupy a portion of the old or present channel from the lock 47 chains to the line of the coast; thence $\frac{263}{1000}$ miles to 17 feet depth of water.

The whole length of the line described and as located, from 17 feet depth of water in the lake to the same depth in the harbor at Brito is $18\frac{90}{100}$ miles, and from the former to the latter coast the distance is $18\frac{325}{1000}$ miles.

The whole fall from the surface of ordinary high lake to the Pacific at the surface of the highest tide observed, is $102\frac{92}{100}$ feet, and to the lowest tide $111\frac{47}{100}$ feet. This latter descent is to be made by 14 locks of 8 feet lift each, except No. 14, connecting with tide-water, which is $7\frac{47}{100}$ feet. They are distributed at favorable locations for construction and subsequent use, and with the exceptions before noticed, the excavation in the several levels between the summit and Brito does not largely vary from the amount required in the banks, and the bottom of the levels, except the three lower, is sufficiently elevated to admit of being drained into the creek.

The material to be excavated at the junction of the River Lajas with the lake is, as before stated, supposed to be gravel: this is

indicated by the gravel surface of the bed of the lake, and of the creek immediately in rear of the bar, the latter of which being only one foot above the bottom of the canal. The dip of the rock which appears above the water at the shore of the lake within ¼ of a mile upon either side, more especially indicates the absence of this material in the line of the channel of the creek at, and several chains back from the lake. Some rock will be encountered in a short cut through the point at a bend in the stream, and in lowering the bottom between this bend and where the line leaves the channel of the creek.

From this latter point, borings were made along the line the entire distance to Brito Harbor, sufficiently frequent to indicate the amount of rock to be excavated. They were, in all cases where no rock was found, carried to the bottom of the canal; and where rock occurred, the earth covering it was bored through, and the rock was penetrated only so far as was necessary to determine its general character at the surface as to being of difficult or easy excavation.

Rock was found in all that portion of the line between the Rio Lajas and the Rio Grande, underlying a covering of earth, varying from 6 to 14 feet in thickness. The rock at no point approaches the general surface: it was visible only in the bed of the deep channel of a brook about 2 miles west from the Rio Lajas; through the summit it consists principally of a wacke, or a variety of trap, apparently harder on the easterly than on the westerly side. A considerable portion of it may be quarried without blasting; the remainder may be readily drilled and blasted.

But little rock will be encountered west of the point of receiving the Rio Grande into the canal, and none worthy of note from where the bottom plane of the canal crosses the bed of the creek, to the termination of the summit level. The borings disclosed no rock between this latter point and the Pacific, and it is believed that in the construction of the canal it will not be necessary to excavate any considerable quantity.

The lock-pits will all be in earth, and in the bottom of those between the summit and the Rio Tolo, 6 in number, will be what is termed dry and sufficiently compact and firm to sustain the foundation of the locks: a portion of the remaining 8 located west from Tola will require bearing piles to sustain them. Two culverts will be required on this part of the line.

(To be continued.)

Mechanics, Physics, and Chemistry.

NOTES ON CRYSTALLOGRAPHY.

By W. H. Wahl.

The polyhedral forms possessing more or less of symmetry, in which many of the inorganic substances composing the crust of the globe occur, are brought about by a property inherent in their smallest particles; a fact which may be proven by direct experiment. A cube of rock salt, or of galena, under a blow of the hammer, gives a multitude of smaller cubes; each of which in turn will yield a multitude of far smaller, but identically the same forms. Let the process be continued to the extremest limit of human capacity; call the microscope to aid, and the hammer still yields naught but cubes. The force, therefore, by the energy of which this form was produced, is a molecular one. It bears the name of the crystallogenic force, and resides doubtless in the molecules of every definite chemical compound or element, though often the physical condition of the substance, or external circumstances have acted as hindrances to its action.

The sphere of the crystallogenic force is limited to that transition point in the physical state of a body, where it is passing from a gas or a liquid into a solid, and the external conditions conducing to its perfect action, must be of such a nature as to admit of that passage taking place, with extreme slowness. In other words, the temperature of the medium from which the mineral is deposited, be it of aqueous or igneous origin, must decrease very gradually, or its evaporation, if the medium be aqueous, must be equally trifling in quantity in a given unit of time. Where these conditions are fulfilled, the substance in solution or in fusion, separates imperceptibly particle after particle, which are definitely positioned and aggregated into a geometrically regular form, according to some well-defined general law of symmetry. Where these conditions are not fulfilled, and the medium separates its material suddenly or quickly, this formative, or arranging force, has no opportunity to act, and the particles, thrown with disorder upon one another, in obedience to no law save that of chance, produce such forms as the accident of place or room may determine.

The first case gives the crystalline, the last the amorphous solid.

A knowledge of the properties of these polyhedral forms, or, as they are usually called, crystals, is often of itself sufficient to determine the specific identity of the substances presenting them; for, with a given mineral, a closer study leads to the conviction, that the most intimate connection exists between its *crystalline form* and its *chemical and physical properties.*

That the crystalline form is related to the physical properties, is proven by its behavior toward the physical agents, light, heat, etc. The crystals of most minerals possess the singular property of doubly refracting the light rays which pass through them, as, for instance, rhombohedrons of Iceland spar, and this property *is common to all rhombohedral crystals.* Others again, as, for instance, cubes of rocksalt, refract the light rays simply, and this property *is common to all cubical crystals.* Many crystals have in certain directions less cohesive power than in others, so that they allow of being readily separated into laminæ along certain planes, called cleavage planes, and the *type* of the crystal determines both the number of these planes or directions, and the degree of the cleavability. Examples might be multiplied, but these are sufficient to testify that the crystal form, determines one or the other of several great categories of physical differences.

That the crystal form holds the closest relationship to the chemical properties is shown by the fact that, for a given chemical composition, the nature of the form is the same; or, what is a more general statement of the same fact, the nature of the form varies with the nature of the body.

This is too evident to need illustration. The most remarkable link, however, connecting these two classes of properties is the phenomenon of *isomorphy*, or, the phenomenon that substances of analogous chemical constitution present the same or analogous crystalline forms. The number, not only of the minerals, but also of the compounds of chemist, which rank as members of numerous amorphous rows or groups, testify to the universality and intimacy of the relation existing here. The so-called alum group, to borrow an example from the laboratory, comprises an assemblage of double salts, in which the bases are variables, but in all of which the same general formula and the same crystalline form is preserved.

To illustrate the influence exerted upon the morphology by the chemical character, no better example can be furnished, viz:—

General formula	$RO\ SO_3,\ R_2O_3\ 3SO_3 + 24\ HO$
Potassa (ordinary) alum	$KO\ SO_3,\ Al_2O_3\ 3SO_3 + 24\ HO$
Rubidia	$RbO\ SO_3,\ Al_2O_3\ 3SO_3 + 24\ HO$
Caesia	$CsO\ SO_3,\ Al_2O_3\ 3SO_3 + 24\ HO$
Soda	$NaO\ SO_3,\ Al_2O_3\ 3SO_3 + 24\ HO$
Ammonia	$NH_4OSO_3,\ Al_2O_3\ 3SO_3 + 24\ HO$
Chrom. potassa	$KO\ SO_3,\ Cr_2O_3\ 3SO_3 + 24\ HO$
Chrom. ammonia	$NH_4OSO_3,\ Cr_2O_3\ 3SO_3 + 24\ HO$
Iron, potassa	$KO\ SO_3,\ Fe_2O_3\ 3SO_3 + 24\ HO$
Manganese, potassa	$KO\ SO_3,\ Mn_2O_3\ 3SO_3 + 24\ HO$
etc., etc.	

In the general formula, therefore, $RO\ SO_3$ represents any alkaline sulphate, and may be written, $Alk\ O\ SO_3$; and the $R_2\ O_3$ can be represented either by $Al_2\ O_3$, $Cr_2\ O_3$, $Fe_2\ O_3$ or $Mn_2\ O_3$, and perhaps even by other sesquioxides.

It requires but the most superficial knowledge of chemistry to recognize the fact, that the metallic oxides replacing one another here, have in their chemical character the closest analogy, and the crystalline forms of all these salts are identically the same.

A crystal is, then, an inorganic solid body, of a more or less symmetrical polyhedral form, which is intimately connected with its physical and chemical properties.

It is the inorganic individual, and being a something of which as much constancy can be predicated, as of any of the other properties of substances; the mineralogist can avail himself of the crystal form of his inorganic material, to determine its specific identity, precisely upon the principle of the zoologist or botanist, who, from the outward form, fixes the species of his organic material.

Parts of Crystals.—In the determination of a crystal, the relations of its various parts, are the data to which the mineralogist appeals. These parts are—

(*a.*) *Faces*, all plane. These are examined with reference to their kind, their number and their relative position.

(*b.*) *Edges*, formed by the meeting of any two forces, their relative lengths, and the inclination of the faces in question in each other (the interfacial angle) are of importance.

(*c.*) *Solid Angles*, formed by the meeting of three or more faces. In the determination, the number and kind of the faces intersecting to form it, and the location of the solid angle are to be considered.

Axes, or imaginary lines draw through their centres, and joining opposite faces, edges or solid angles, can be constructed for every crystal; and it is mainly by their use, that amidst apparently end-

less complexity, many forms, totally different in appearance, and seemingly altogether unrelated, are shown to be referable to one and the same type of growth, and that all the multitude of crystals can readily be classified into a few groups, governed by simple but decided formative laws. The crystallographer does not construct for each form all the possible axes, but adopts a system, generally three (sometimes of four), which has proven to be applicable to, and sufficient for, a clear systematization of all the forms, as yet observed, from the simplest to the most complex.

If a complete crystal be examined it will generally be found that for every face, edge or solid angle, another and *similar* face, edge or solid angle exists opposite to it. The axes then, necessarily end in, or join equal, but opposite parts.* Accordingly, they serve as a complex of lines or directions about which the various parts of the crystal are symmetrically located.

If, however, after having accomplished this symmetrical positioning for a number of crystals, attention is turned to the axes themselves, and a comparison is instituted between the axial cross of each crystal, and that of its neighbor; a number of differences meet the eye. Some crystals will be found to require four axes, others only three; in some, the axes intersect at right angles, in others, axial intersection forms an oblique angle; in some, the axes are all equal in length, in others, the lengths of the axes are unequal.

With these axial differences, too, the physical differences formerly referred to are intimately associated. To give the examples most commonly mentioned:—Where the axes are of equal lengths, the light rays are, in their passage through the crystal, refracted simply; where they are unequal, double refraction takes place. Or again, if, upon a crystal having three equal axes, cleavage should exist parallel to *one* of them, it exists in an equal degree, parallel the *other two;* with a crystal having two equal and one unequal axis, any degree of cleavage existing parallel to one of the *equal* axes, must manifest itself in like degree parallel the *other*, but may exist in a more or less perfect degree, or may be altogether absent parallel the unlike axes; with a crystal having three unlike axes, the cleavage in each of the three directions may be a *different* one.

Such differences as these point to complete differences in internal structure, and furnish the basis for the establishment of the various crystal systems.

* For some of the so-called *hemihedral* crystals axes may be constructed, which end in unlike parts, but they offer the exception, not the rule.

Nomenclature.—The necessity amidst a multitude of forms, of giving to the mind a clear conception of each, by means of concise and universally applicable modes of expression is too apparent to require argumentation. Hence, crystallography, like other of the physical sciences, requires a language of its own. There are several of these nomenclatures in vogue, all of which, however, are based upon the same principle, namely, to express simply and completely for each form the relation of any one of its faces to the three (or four) axes. By relation is here meant the relative distances from the centre of the crystal (the point at which the axes intersect), in which the axes are cut by the faces.

This expression obtained for one of the faces is the expression for all, as each face is but a repetition of its predecessor. The nomenclature of Naumann has come into almost general scientific favor, and its modification, or perhaps better, its simplification by Dana, obtains universally amongst us. Aside, however, from its growing popularity, its superiority in point of completeness and simplicity over all others, should give it the preference in this treatise.

To illustrate its application in the following pages, let a few simple examples serve:—

A crystal is before us, whose axes are equal. Let any one of its faces then be chosen, and its relation to the axes be determined.

Suppose it to cut one of the axes in a certain distance:—for illustration's sake, call this distance, a. Let it cut the second and third axes, in the same distance, a. The position then of this, and of all the faces of the crystal, expressed in distance measured upon the axes will be $a : a : a$. If the numerical value of a is determined, the expression assumes definiteness. For the value, 1, for instance, it becomes $1 : 1 : 1$. Again, a form with the same axes is before us:—its faces cut one of them in the same distance, a, but will not cut the second and third axes, unless the faces, as well as the axes in question are imagined to be prolonged beyond the crystal. The distance from its centre to where the prolonged plane and axes meet, is, let us say, twice the distance a. Its formula would be $a : 2a : 2a$, or, with the same value for a as that assumed above, $1 : 2 : 2$.

The faces of another form, cut one axis in a, but are parallel to the other two axes (*i. e.* cut them in an infinite distance). Its formula, therefore, would be $a : \infty a : \infty a$, or as with the others, $1 : \infty : \infty$.

A still more simplified expression will be obtained, if we *imagine* as Dana does, instead of *expressing* the value 1 in the formula. The first form he expresses simply by 1 instead of 1 : 1 : 1.

The second would become simply 2 : 2; and the last, instead of 1 : ∞ : ∞ would be written *i i* (where *i* the initial letter of the word infinity is used instead of the mathematical symbol ∞.)

(To be continued.)

CHEMICAL TABLES ACCORDING TO THE THEORIES OF MODERN CHEMISTRY.

BY PROF. ALBERT R. LEEDS.

(Continued from Vol. LIX., page 423.)

In the Comptes Rendus, XX., 1047, will be found another series of careful and laborious determinations of certain atomic weights by Pelouze. Other valuable contributions to our knowledge in this direction will be found in the Bibliotheque Univ. de Genéve, XLVI., by De Marignac, and by Erdmann and Marchand, in the J. f. prakt. Chem., XVIII., XXVI., XXXI. and XXXIII. A brief synopsis of the processes and results which are given in the above-cited memoirs is appended to Miller's Elements of Chemistry, Part II., p. 859. For special contributions to our knowledge of the at. wts. of antimony, cadmium and lithium, consult Chem. Centr., 1857, 454 and 897; Wien. Acad. Ber., XXV., 118; J. pr. Chem., LXXII., 338; Ann. ch. phys. [3] LI., 103; Sill. Am. J. [2] XXVIII, 349; Am. Ch. Pharm., CXXI., 93; Compt. Rend, LIV., 366. Abstracts and references concerning the at. wts. of Caesium, Rubidium and Thallium, will be found in the Jahresbes. der Chem. In a recent number of the J. pr. Chem., 1869, Rammelsberg has re-calculated the at. wts. of Tantalum and Niobium (Columbium) after the analyses of Rose and De Marignac. In the Amer. J. Sci. [2] XLVI., 53, Dr. Genth has published the redetermination of the at. wt. of Cerium, by Dr. C. Wolf, and his results are here accepted as representing at present the closest approximation to the truth. For the at. wts. of Erbium and Yttrium, consult the memoir by Bahr and Bunsen, in the Am. Ch. Pharm., CXXXVII., 1, and for Terbium that by Delafontaine, same journal, CXXXIV., 99. Two series of independent analyses are given by Winkler, in the J. pr.

Chem., CII., 273, the mean of which makes the at. wt. of Indium 37·81. To Vanadium Roscoe assigns an at. wt. of 51·33, Phil. Mag., [4] XXXV., 307.

De Marignac assigns to Didymium the at. wt. 47·92, Am. Ch. Phys. [3] XXXVIII., 148; to Lanthanum the concordant results of Mosander, Holzmann and R. Hermann, give 46·4, J. pr. Chem., LXXV., 321, and LXXXII., 385. Our information concerning Ruthenium is almost entirely derived from the labors of Claus, Ann. Pharm. LVI., 257, LIX., 234 and LXIII., 259, which makes its at. wt. 52·1. From a careful perusal of the chemical testimony adduced in the foregoing memoirs as to the true at. wts., Table III. of the Atomic Weights, according to ancient chemistry, has been derived. Where the chemical testimony appeared equally strong for different values of the at. wt. of any element, the Law of Specific Heats and Isomorphism have afforded help in the decision. It is not expected that others would be impressed in precisely the same way by a similar examination of these data. But it is hoped that the table here given will commend itself as an accurate and impartial summary of our present knowledge, and that it may be taken with safety and advantage as a groundwork for the tables which follow. Appended to the at. wt. of each element is the authority upon which it rests. In every case, the result of the analyses themselves is given, and not the at. wt. deduced from them in accordance with Prout's law or any other theoretical consideration. Neither has the mean of the at. wts. obtained by several observers for any element been taken, because we do not thus necessarily arrive at a truer approximation.

Upon Table III., as a foundation, Table IV. has been built up in agreement with the hypotheses of modern chemistry. To mention what these hypotheses are, and in what manner they have been applied to the at. wts. of each element, would be vastly beyond the reach of our present purpose. They involve the labors of Kolbe, Kekulé, Hofmann, Frankland, Williamson, and a host of others who have projected and established the new chemical system.

In some cases, the at. wts. which are given as those of Berzelius, in the Table, according to Ancient Chemistry, are half of what he himself adopted. In regard to the at. wts., the opinions of Berzelius, in many instances, were juster than those of the chemists who followed him—they retrograded.

TABLE I.

Atomic Weights according to the Original Observers.

ELEMENT.	BERZELIUS.		Other Observers.
	O = 100	H = 1	O = 100. H = 1.
Aluminum.........	170·90	27·39	13·744, Dumas.
Antimony..........	806·452	129·24	120·3, Schneider; 120·69, Rose; 122·34, Dexter; 122, Dumas.
Arsenic.............	469·40	75·225	75, Peloze; 74·95, Dumas.
Barium	855·29	137·07	68·51, Dumas; 68·64, Pelouze; 68·58, De Marignac.
Bismuth	1330·377	213·20	[1330·377, Lagerhjelm, adopted by Berzelius]; 210·34, Dumas.
Boron..	136·204	21·83	[136·204, Boracic Acid being regarded by Berzelius as BO_3;] 11, Dumas.
Bromine.............	499·81	80·102	[499·81, De Marignac, adopted by Berzelius.]
Cadmium	696·767	111·66	[696·767, Stromeyer, adopted by Berzelius;] 56·12, Dumas; 56, C. v. Hauer.
Cæsium	....	....	133·00, Johnson and Allen.
Calcium	251·651	40·329	20·01, Dumas; 20·03, Erdmann and Marchand; 20·105, De Marignac.
Carbon	75·12	12·04	75·005, Dumas; 6·007, Erdmann and Marchand; 6·06, Liebig and Redtenbacher.
Chlorine............	221·64	35·52	[221·64, De Marignac, adopted by Berzelius;] 35·505, Dumas; 35·476, Maumené; 35·46, Stas.
Chromium	328·38	52·63	[328·38, Berlin, adopted by Berzelius;] 26·24, Péligot.
Cobalt..	368·65	59·08	[368·65, Rothoff, adopted by Berzelius;] 29·54, Dumas; 30, Schneider.
Columbium........	....	....	98·45, Rose and De Marignac, recalculated by Rammelsberg.
Copper...............	395·60	63·40	396·6, Erdmann and Marchand.
Didymium...........	....	....	47·92, De Marignac.
Erbium...............	....	....	56·3, Bahr and Bunsen.
Fluorine.............	117·717	18·865	19, Louyet; 19, Dumas.
Glucimum	87·124	13·96	[87·124, Awdejew, adopted by Berzelius.]
Gold...................	1229·165	196·99	
Hydrogen..........	6·24	1·00	12·5, Dumas; 12·5, Erdmann and Marchand.
Indium...............	....	....	37·813, Winkler.
Iodine................	792·996	127·08	[792·996, De Marignac, quoted by Berzelius;] 127, Dumas.
Iridium..............	1232·08	197·46	
Iron...................	350·527	56·18	350·59, Svanberg and Norlin; 350·1, Erdmann and Marchand: 28·07, Dumas.
Lanthanum........	....	....	46·4, Mosander, Holzman, and R. Hermann.
Lead..................	1294·645	207·46	103·5, Dumas; 103·456, Stas.
Lithium	81·66	13·087	6·97, Mallet.
Magnesium........	158·14	24·76	12·11, Scheerer; 12·35, Svanberg and Nordenfeldt; 12·3, Dumas.
Manganese.........	344·684	55·24	27·48, Dumas.
Mercury............	1251·29	200·53	[1251·29, Erdmann and Marchand, quoted by Berzelius;] 1265·823, Sefström.
Molybdenum......	596·10	93·36	46·06, Svanberg and Struve; 48, Dumas.

TABLE I.—*Continued.*

ELEMENT.	Berzelius. O = 100	Berzelius. H = 1	Other Observers. O = 100. H = 1.
Nickel	369·33	59·19	[369·33, Rothoff, adopted by Berzelius:] 29·51, Dumas; 29, Schneider.
Nitrogen	88·52	13·708	[88·52, De Marignac, adopted by Berzelius;] 14, Dumas; 14·041, Stas; 13·95, Anderson and Svanberg.
Osmium	1242·624	199·14	
Oxygen	100·00	16·026	
Palladium	665·477	106·65	
Phosphorus	196·0205	31·414	32·02, Pelouze; 31·03, Dumas; 31, Schrötter.
Platinum	1232·08	197·0	98·94, Andrews.
Potassium	488·856	78·34	[488·856, De Marignac, adopted by Berzelius;] 38·95, Maumené; 39·14, Pelouze. 39·13, Stas.
Rhodium	651·962	104·48	
Rubidium	....	....	85·4, Bunsen.
Ruthenium	....	....	52·1, Claus.
Selenium	495·285	79·374	
Silicon	277·778	44·52	[Berzelius regarded Silicic Anhydride as SiO_2;] 14·24, Pelouze; 14·01, Dumas.
Silver	1349·66	216·29	107·97, Maumené; 107·945, Stas.
Sodium	289·729	46·43	22·97, Pelouze; 23·01, Dumas; 23·05, Stas.
Strontium	545·929	87·49	[545·929, Stromeyer, adopted by Berzelius;] 43·97, De Marignac; 43·84, Pelouze; 43·74, Dumas.
Sulphur	200·75	32·17	16, Dumas; 32·074, Stas.
Tantalum	1148·365	184·04	182, Rose and De Marignac, recalculated by Rammelsberg.
Tellurium	801·76	128·51	64·5, Dumas.
Terbium	....	....	37·68, Delafontaine.
Thallium	....	....	203, Crookes; 204, Lamy.
Thorium	743·86	119·21	
Tin	735·294	117·84	58·05, Mulder; 59·03, Dumas.
Titanium	301·55	48·33	[301·55, H. Rose, adopted by Berzelius;] 25·17, Pierre.
Tungsten	1188·36	190·45	92, Dumas.
Uranium	742·875	119·06	[742·875, Ebelman, adopted by Berzelius.]
Vanadium	856·892	137·33	51·33, Roscoe.
Yttrium	....	....	30·85, Bahr and Bunsen.
Zinc	406·591	63·69	[406·591, Erdmann, adopted by Berzelius:] 414·0, Jacquelain; 412·5, Favre.
Zirconium	419·728	67·26	[419·728 when, as regarded by Berzelius. Zirconia is Zr_2O_3.]. According to DeMarignac and Dumas, Zirconia is ZrO. Then the atomic weight is 22·4.

(To be continued.)

ON THE NEW CHEMICAL NOMENCLATURE.

By Dr. Adolph Ott.

(Continued from Vol. LIX., page 52.)

According to the new system, a molecule of water is represented by notation $\left.\begin{matrix} al \\ al \end{matrix}\right\} at$ and symbols $\left.\begin{matrix} H \\ H \end{matrix}\right\} O$, and applying the term for two atoms of hydrogen, used in the table of metalloids, its name is *hydrelat.* Nevertheless, *el* expresses precisely the same as *hydrel*, therefore the terms may be contracted to *elat*, which is virtually *al*, *al*, *at*. As the consonant *g* is only used to express the gaseous state of a simple or compound body, a molecule of steam is *gelat.* In the crystalline state, whether as ice, or as a component part of a crystallized salt, a molecule of water is represented by *allt*, and it should here be noted that this is the only case in which the consonant symbolizing an element is doubled to denote two atoms. The vowel at the commencement of the word determines the quantity of water, thus *ollt* is four and *eillt* is eight molecules of water. The author of the "New Nomenclature," Prof. S. D. Tillman, through this most ingenious device, has furnished the means of expressing the amount of constitutional water, found in a large number of metallic salts, by affixing a single syllable to the respective new names. It is hardly necessary to observe that this is the first time such expression has been attempted, since all previous names of such salts give no indication of the existence of any water in their composition. Another variation of the term shows how replacements are made in hydrated metallic oxides, thus *alalt* being also a molecule of water, the substitution of an atom of potassium for the first *al* gives us *potamalt* as the name of the hydrate of potassa, and thus, as the atomic weight of calcium has been doubled, it replaces a like atom of hydrogen in each of two molecules of water, it is quite apparent that the true composition of the hydrate of lime is expressed by the single word *calcamelt.*

Perhaps the most curious and important modification of the names of water is that by which our author represents it when not in true chemical combination, that is the indefinite quantity by which it often becomes a solvent. It should have been stated earlier, that in the formation of the hundreds of terms required for organic compounds, the author found it essential to use *h* (when in

combination with other letters) to represent two atoms, or a molecule of hydrogen, thus giving an old symbol its true value in the new notation. In nearly all the new names, the author has succeeded in giving a correct idea of the electro-chemical tendency of each element by the position of its symbolic letter in the word, the most electro-positive element being represented by the first letter and the most electro-negative by the last letter of the term. Thus *elat* shows that hydrogen is the positive, and oxygen the negative element; however, when water does not enter the chemical combination, it is not essential to keep up this distinction and the author always using *t* for oxygen, in this case places it before *h* denoting the double atom of hydrogen, and thus represents the great solvent by *th*. A single example will suffice to show how wonderfully chemical terms have by this means been abbreviated, while absolute correctness has taken the place of the most ambiguous and confusing expressions. The term "soda water" is now applied to a pleasant beverage, which contains no soda, simply because soda was formerly used in its preparation. Yet the term gives the person regaled by it not the slightest idea of what elements are held in solution by this water. Now, as carbonic acid consists of one atom of carbon and two atoms of oxygen, *carbar et*, or simply *aret*, expresses the compound condensed to a liquid, while *garet* denotes carbonic acid gas. When this gas is forced into pure water by pressure, a most agreeable and healthy drink is produced, whose peculiar composition is aptly expressed by *tharet*.

By the same admirable method, the author gives us a brief and euphonious name for the compound called "spirits of hartshorne," and often misnamed ammonia. Pure ammonia being a combination of three atoms of hydrogen (*il*) with one atom of nitrogen (*an*) ammoniacal gas is designated by *gilan*, and a solution of this gas in water—for which it has great affinity—is simply expressed by *thilan*.

Again, sulphurous acid gas being a combination of two atoms of oxygen (*et*) with one atom of sulphur (*sulphas* or *as*), sulphurous acid is designated by *gaset*, and a solution of this gas in water, absorbing about forty times its own volume, is expressed by *thaset*. And it may be here said, that these compounds once learned by their new names have their composition absolutely and indelibly fixed in the memory.

It will furthermore be observed that Professor Tillman's atomic

names given in the preceding chapter, are applicable to the new notation already adopted by a large majority of European chemists; and a word of explanation as to the cause of this change in the notation will not be here out of place. Berzelius first saw the inconsistency of Dalton in regarding the hydrogen atom as twice as large as that of oxygen. The reasoning on this subject was very simple, yet convincing, water decomposed yields twice as much hydrogen as oxygen gas, in other words, two volumes of hydrogen to one of oxygen, and if one-half of this hydrogen could be displaced, it was evident that the number of atoms must conform to the number of volumes, and that water must be regarded as a combination of two atoms of hydrogen with one atom of oxygen, consequently the combining weight of hydrogen must be taken at one-half its former value on the oxygen scale of combining weights, in which oxygen was fixed at 100. The hydrogen scale of atomic weights in which the combining number of hydrogen was taken as the unit, required a similar change and water represented by symbols would therefore be:—

$$\left.\begin{matrix} h \\ h \end{matrix}\right\} \mathrm{O}, \text{ instead of H O,}$$

in which O was equal to 8 and h equal to 0·5 and $h + h =$ H or 1.

Gerhardt, at a later day, perceived the necessity of making the volume uniform to the atom, but he also saw the importance of making the specific gravity of elementary gases conform with the weights, and as oxygen was sixteen times heavier than hydrogen, he proposed that the atom of hydrogen should be taken as the unit, and that the symbol of water should be $\left.\begin{matrix} \mathrm{H} \\ \mathrm{H} \end{matrix}\right\} \mathbf{O}$ in which the ratio is 2 to 16, instead of 1 to 8.

The law of Gay Lussac, that gases combine in equal volumes or in simple multiples of an equal volume, was thus made more apparent. A volume of nitrogen being 14 times heavier than a volume of hydrogen, the atomic weight of nitrogen is 14, and a volume of chlorine being 35·5 heavier than a volume of hydrogen, the atomic weight of chlorine is 35·5. It was found that the atomic weights of the other three halogens, fluorine, bromine and iodine remained as before, respectively, 19, 80 and 127, while those of carbon and sulphur required to be doubled, and are now taken, respectively, at 12 and 32. Phosphorus and boron atoms retain their former weights, while those of silicon and selenium are doubled.

It will be seen that the sum of the atomic weights of organic compounds remains, for both views, the same as the following notation for hydrated acetic acid will show.

$$\begin{array}{cc} \underbrace{C = 6.\ \ O = 8.\ \ H = 1.} & \underbrace{C = 12.\ \ O = 16.\ \ h = 1.} \\ C^4 = 24 & C^2 = 24 \\ H^4 = \ \ 4 & h^4 = \ \ 4 \\ O^4 = 32 & O^2 = 32 \\ \overline{\quad} & \overline{\quad} \\ 60 & 60 \end{array}$$

It was subsequently ascertained that the atomic weights of all the metals excepting silver and those of the alkalies must be doubled in order to conform to the new notation. The further changes required in the non-metallic and metalloid elements will be seen by reference to the tables already given. To distinguish those symbols which had been doubled in value, Gerhardt proposed to use barred letters, but as they are not to be found in an ordinary font of type, we have indicated the change in the tables of the preceding paper by thick-faced type. The adoption of Professor Tillman's system of nomenclature requires the use of only the ordinary type, since he has fixed the values of the consonant symbols in accordance with the new notation. To make the combinations of atoms extremely plain and simple, only the terminals of the names of the non-metallic elements are used, as already partially explained. Hydrochloric acid being a combination of one atom of hydrogen or *hydral* with one atom of chlorine or *chlorad*, it is evident that the combination of the terminal syllables will express the same meaning, thus *alad* denotes the union of these two elements, and as the prefix *g* invariably denotes the gaseous state, the word "*galad*" has the same meaning as the three words "hydrochloric acid gas."

The formation of a haloid salt from a haloid acid consists simply in the substitution of an atom of alkaline metal for one of hydrogen, and in the case of hydrochloric acid, for example, Prof. Tillman has given the simplest possible explanation by showing that *alad* is only changed to *amad*, which is the terminal of every salt be-belonging to this class. Thus chloride of sodium or common salt is *sodamad*, chloride of potassium is *potamad.*

Hydrofluoric acid being an atom of hydrogen, combined with one of fluorine, its composition is fully expressed by *alaf*, and that of fluoride of sodium by *sodamaf.* Hydrobromic acid being

alab, bromide of lithium is *lithamab*, and hydriodic acid being *alav*, iodide of potassium is *potamav*. The metals whose atoms by general consent have been doubled form salts of this class to which the old nomenclature is no longer applicable, yet their actual composition is most clearly shown by the new system; for example, mercurous chloride, as it has been lately termed, or common calomel, is *mercamad*, while mercuric chloride, or corrosive sublimate, is *mercamed*. The reactions of hydrocyanic or prussic acid are similar to those of other haloid acids. Formerly it was regarded as a combination of an atom of hydrogen with two of carbon and one of nitrogen; the atomic weight of carbon having been doubled, this compound consists of one atom of each of those elements, which is expressed by the new name *alarn*, and thus the composition of cyanide of potassium is shown by the new word *potamarn*, and that of cyanide of barium, (the barium weight being doubled) by *baramern*. Thus, too, the compound formerly called the terchloride of gold, since the gold atom has also been doubled in weight, must contain six atoms of the radical, and has the appropriate name *auramcarn*. Nitric acid being monatomic is *al-anit*, and nitrate of silver containing an atom of silver (*argam*, from argentum), instead of one of hydrogen, is expressed by either *arganit* or *silmanit*, and nitrate of potash or saltpetre containing an atom of potassium, *potam*, is designated by *potmanit*. As an atom of a biatomic metal will displace two atoms of hydrogen this double atom of acid may be expressed by *el-eneat*, (*ea* to be pronounced as in *great*), and thus the nitrate of baryta becomes *barmaneat*. Sulphuric acid is biatomic, and under the old system was regarded as an atom of water united with one of acid, or HO with SO_3 equal to $H+SO_4$, and as the atomic weights of sulphur and oxygen have been doubled, two atoms of hydrogen are required, thus we have for the name of this acid *el-asot*; all salts of metals with this acid have the same termination—for example, sulphate of lime is *calmasot*, sulphate of baryta is *barmasot*, sulphate of zinc *zinmasot*. Carbonates have the terminal *arit*, *e.g.*, carbonate of lime *calmarit*, carbonate of soda *sodemarit*.

(To be continued.)

Telegraph.—The latest advices state that the British Australian Telegraph is in a fair way to be harmoniously and rapidly completed.

ON A SIMPLIFICATION IN THE CONSTRUCTION AND USE OF THE HOLTZ MACHINE.

BY J. C. POGGENDORFF.

(Translated from the Ann. d' Phys. und Chem., pp. 139—158.)

BY PROF. LEEDS.

THIS machine, it is well known, consists of a movable and a fixed glass disk. The latter is cut out in sectors, which open toward the edge, or in circular or oval openings. The latter is the better arrangement, and at the present time in general use, because the position of such a fixed disk can be altered with ease.

Concerning the advantage and necessity of these openings, no precise opinion has, to my knowledge, as yet been published. Mr. Holtz mentions incidentally in his first memoir, that the use of the openings is, to interrupt the binding influence of the electricity, collected upon the hinder side of the fixed disk, and thus to set free the electricity of the revolving disk. This theory has never been plain to me, and I became altogether perplexed when I found that these openings or windows (as the French say) can be replaced by glass or vulcanite under certain circumstances, without detracting notably from the performance of the machine. Since, however, I perceived no gain from their closure, I left the matter lie.

Since that time I have observed, among other things, that the machine can be excited in three ways. First, from the hinder side in the usual manner, by conveying electricity to one of the paper strips. Secondly, from the front, by allowing electricity from another source, either a machine or a charged flask, to stream out upon the revolving disk, after that it has been oppositely excited in its two halves by previous use of the machine, and the strips have been touched to discharge them of their electricity.

In whatever way the machine was excited, I always found that the tooth of the strip, during the rotation of the disk, was not simply electrified, but is in a polar condition, by virtue of which it sends out electricity of one kind from its point, and the opposite from its base. If, for example, positive electricity is conveyed to the point, by contact with the positive knob of a charged flask or with the plate of an electrophorus, then this point does not give out positive electricity during the rotation, but negative. The positive makes its way to the base of the tooth that stands directly opposite the neighboring comb, which in this case discharges negative electricity. On the contrary, when negative electricity is allowed to

stream out upon the rotating disk through a comb, the strip standing opposite, as well as the base of the tooth, give out positive electricity, and the point of the tooth negative.

I convinced myself by these experiments that the paper strip, even when varnished, (which is now generally left undone,) is, like the tooth a conductor, and necessarily must be. A toothed strip of mica, a non-conductor, is of no use. On the contrary, the paper can be replaced quite well by tin-foil, which is a metallic conductor. Not, however, with practical gain, because, on account of the rapid escape of electricty, the working is much feebler, and soon ceases if the electrodes be rather widely separate. How much the electricity escapes from such a strip is strikingly shown, when the strip is positive and the point of the tooth negative; in the dark long slender sparks are seen to shoot forth from it. Mr. Holtz was happy in selecting just such a half conductor as paper for the strips.

These and other phenomena, which strengthened me in the opinion that the paper strips of the machine were not comparable to the cake of an electrophorus, gave me a clearer insight into the function of the windows in the fixed disk.

I perceived that these windows have and can have no other use than to convey the electricity streaming out from the base of the teeth to the strips connecting with them over the edge, and thus to spread it over the outer side of the disk. And hereby a construction was given, which makes the windows superfluous.

I caused two diametral holes, about 18 mm. diameter, to be bored in the fixed disk, closed both by a disk of cork, and glued upon their inner sides the paper teeth, and upon their outer the paper strips. In this way, without the windows, a conduction was established between the teeth and the strips. My expectations from this construction were entirely fulfilled. Neither in the length of spark nor in the quantity of electricity did I find that it differed notably from the machine with windows Only it was necessary to bend the teeth so that their points might lie in the middle of the interval between the two disks. This construction makes the machine cheaper, since the boring of a small hole is much less costly than the cutting of windows with a diamond, whereby the disks often fracture.

But it presents still other advantages. Firstly, a clear proof can thus be obtained, that strips on the outer and teeth on the inner side of the fixed disk, are essential to the working of the machine.

If this disk be turned around, so that the strips lie inward and the teeth outward, the machine does not perform, even though the movable disk be rotated in a contrary direction, *i.e.*, against the points of the teeth.* Secondly, the single and double quantity of electricity can be generated with the same machine, without making use of more than one fixed disk, especially if the machine be provided with the new arrangement by Mr. Holtz of a one-sided axle.†

To fit the machine for generating a double quantity of electricity, it must, as is well known, be provided with four combs. For this reason, to the usual fixed disk still a second, with four toothed strips has been added. At the same time, it has been proposed to observe the working of the machine thus altered between the same electrodes, which are made use of in a machine with only two windows. This, however, made a very complicated mode of connection between the combs necessary, since the striking distance of such a machine, for some cause hitherto unexplained, is always very small. The electrodes can never be separated very widely—an inch at the utmost.

For changing flasks for producing long sparks and brushes, such a machine is not fitted; its use is mostly limited to the luminous effects with rarified gases. Here it has a real superiority to the simple machine.

My method of arriving at the proposed end is as follows: First of all I provide the fixed disk with four toothed strips of the kind described, about a quadrant distant from each other. I have convinced myself that this does not interfere with the employment of only two strips, for the production of a single quantity of electricity. If I lengthen out each of the small horizontal strips, by a quadrant shaped strip of thin writing paper above, and below by as much, and insert the wire, I obtain the same length of spark and amount of electricity, as when the fixed disk under like circumstances has only two strips with open windows.‡

* I have also found by trial, that teeth on the inner side of the windows without strips on the outer, or the reverse, do not operate.

† A disk with four windows can be used with two combs, indeed, but it has always appeared to me that the quantity of electricity and the spark length are less in this arrangement than in that of a disk with only two windows.

‡ To the perplexing phenomena in which the machine is so rich, there belongs among others this: that when both the bow shaped paper strips, which, as mentioned above, lengthen out the small horizontal strips, reach only on one side to the wire, reversions of the current occur so soon as the electrodes are widely

In order now to obtain a double quantity of electricity, it is necessary, after both the bow-shaped assisting strips are separated, to place the wire perpendicular, and shove the electrodes close together, so that the combs placed diametrally are connected in pairs, and stand before the strips. If now between the wires, *i. e.*, between the vertical wire and the horizontal electrodes a connection be established, as, for example, through a vacuous tube, then the double quantity of electricity is obtained in it as soon as the machine is excited in the usual way. This excitement follows instantaneously from rubbed vulcanite or the electrophorus plate, but not until all the four combs are connected.

In order to effect the above mentioned connection easily, the wire in front, in the prolongation of the pin by means of which it is fastened to the axle of the machine, is provided with a hollow continuation of about an inch and a half long and half an inch thick, which carries a ball on its end. Against this, the insulated ball of a small adjustable stand is pushed, and the latter brought into connection with the electrode bows by means of the Geissler tubes under examination. The object of this arrangement is to make it possible to use at will the direct, the interrupted or the explosive current. In the first case the balls are pushed together; in the second they are pulled some way apart; in the third a pair of small flasks is added. These are laid the one upon the continuation of the wire, the other upon the electrode-bows, their exteriors being connected.

All this is much longer to describe than to do. In two minutes at the utmost, the machine from giving a single is arranged to give a double quantity of electricity, and quite as quickly changed back again, without taking it apart as was formerly necessary. I believe, therefore, that it will conduce to the end in view, to arrange all machines in future, especially those with the one-sided axle, in the manner described.

If, however, it was designed to investigate more narrowly the function of the fixed disk, it would perhaps not be superfluous to add to the machine a fixed disk with only two-toothed strips.

separated. I have not always noticed such reversions. I have not noticed them with flash discharges, but only with brushes. But yet the new arrangement is notably inferior to the old (with windows), which appears to be free from this drawback.

The spark length is as wonderful as anything attendant upon these reversions. Frequently, neither in the old nor in the new arrangement can this be brought to a maximum. It is evident that the current in the wire, at these times, has a great intensity. Now, it is conceivable that the current between the electrodes must diminish as it increases in the conductor, but why, under the circumstances, it is hard to explain. The cleanliness of the glass surfaces, moreover, has a great influence upon these anomalies.

(To be continued.)

ANALYSIS OF SOME HITHERTO UNDETERMINED AMERICAN MINERALS.

BY PROF. LEEDS.

I.

A greenish-white, translucent, compact mineral from Van Arsdale's quarry, near Attleboro', Bucks County, Pennsylvania, previously regarded as Ekebergite.

Sp Gr. 2·71

Percentage Composition.

SiO_2	47·47
Al_2O_3	27·51
Fe_2O_3	tr.
MgO	1·20
CaO	17·59
Na_2O	3·05
K_2O	1·40
H_2O	1·48
	99·70

The Atomic Ratio, obtained by multiplying the quotients of these per cents by the atomic weights into the quantivalences of the radicals is:

Si	$0·79 \times 4 = 3·16$	3·16 or	12
$[Al_2]$	$0·27 \times 6 = 1·62$	1·62	6
Mg	$0·03 \times 2 = 0·06$		
Ca	$0·31 \times 2 = 0·62$		
Na_2	$0·05 \times 2 = 0·10$		
K_2	$0·015 \times 2 = 0·03$		
H_2	$0·08 \times 2 = 0·16$	0·97	4

Excluding the percentage of water, as has been done hitherto in the computation of the formulæ of these and analogous silicates, we have for the atomic ratio, 1 : 2 : 4. If we deduct the amount of Si corresponding to the H_2, regarding the matter as existing in the mineral in the form of Hydrate of Silicic Acid, we again have the ratio 4 : 6 : 12, and the formula $(Ca, Na_2)_2\ [Al_2]\ Si_3\ O_{10}$. And the mineral is Scapolite.

The same mineral is found in the locality mentioned above in imperfect crystals with rough faces. It is associated with Pyroxene, Graphite, Sphene and Phlogopite in Granular Limestone.

II.

A variety of Orthoclase which is described by I. Lea* as being of a dull bluish-green color, and semi-transparent, with very minute crystalline hexagonal plates disseminated through the mass and giving out very bright reflections. These plates may be seen with the naked eye. The name proposed for this variety was *Cassinite.* It is found in a ploughed field on a serpentine ridge known as Blue Hill, in Upper Providence Township, Delaware County, four miles north-west of Media.

Percentage Composition.

SiO_2	64·20
Al_2O_3	19·69
Fe_2O_3	0·69
CaO	2·27
MgO	0·15
K_2O	9·59
Na_2O	3 43
Ign	0·27
	100·29

Its formula is (K_2, Na_2) $[Al_2]$ Si_6, O_{16}, the same as common Orthoclase.

III.

A yellowish white mineral with rhombohedral cleavage and vitreous lustre, occurring imbedded in Steatite. It is associated with a ferruginous Dolomite, and often intermixed with it: becomes brown on exposure. It is found at the soapstone quarry on the north-east bank of the Schuylkill river, on the line between Philadelphia and Montgomery County.

Percentage Composition as given by the Mean of two Analyses.

MgO	38·43
FeO	10·39
CaO	3·29
CO_2	47·96
	100·07

It is to be regarded, therefore, as a Ferriferous Magnesite or Breunerite.

My thanks are due to Mr. Theodore D. Rand, who obtained the specimens of these three minerals at the localities, and kindly presented them to me for analysis.

* Proceedings of the Academy of Natural Sciences of Philadelphia, 1866.

SPECTROSCOPIC NOTES.

By Prof. C. A. Young, Ph.D., of Dartmouth College.

Spectrum of a Solar Spot, April 9, 1870, *P.M.*

Examined the spectrum of a large group of spots a little north and east of the sun's centre.

The nucleus of the most southerly member of the group reversed the C line finely, turning it into a conspicuous bright line for about 20″ of its length, without any distortion, however, such as is common upon this (dark) line in the neighborhood of spots.

F was also reversed, but rather faintly.

D_3 could not be made out at all in the nucleus spectrum; neither were 2796 (the numbers refer to Kirchhoff's map) nor *h* reversed. I thought, however, that they were somewhat *thinned*.

The reversal of C and F continued through the whole afternoon.

On the other hand, many of the dark lines were widened and deepened in this nucleus spectrum in the manner which the description and figures of Mr. Lockyer have made familiar. Many also were unaffected. Among these were notably *a*, B, E, 1474, the four lines of *b*, 1691 and G.

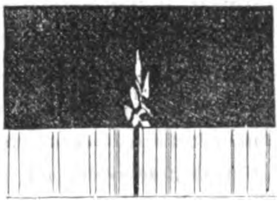
The two sodium lines D_1 and D_2, and 850 (Fe) were distinctly, but not greatly, widened.

The effect was most marked upon the following: 864 (Ca), 877 (Fe?), 885 (Ca), 895 (Ca and Li), 1580 (Ti), 1599 (Ti), 1627 (Ca), and 1629 (Ti). I have marked 877 doubtful, because there lies very near it a line whose origin is unknown, and I am not sure to which of the two the thickening was due. The Titanium lines are identified as such by reference to Angström's Atlas. I was greatly surprised at the prominence they assume in the spot-spectrum, as they are inconspicuous in the normal spectrum; and a similar remark applies to the calcium lines.

I do not intend to convey the idea that the lines mentioned were the only ones that were much deepened; there were many others, mostly faint, affected to nearly the same degree, but I had not time to identify them.

There was at the same time an exceedingly brilliant protuberance on the south-west limb of the sun (position angle 230°), near but not over, a large spot which was just passing off. At the base of this prominence, which was shaped like a double ostrich plume,

the C line was intensely brilliant, so that the slit could be opened to its whole width in studying the form above described, but it was not, so far as I could see, in the least distorted. On the other hand, the F line, also very brilliant, was shattered all to pieces, so that at its base it was three or four times as wide as ordinary, and several portions of it were entirely detached from the rest. The figure, without pretending to exact accuracy, and for the sake of distinctness a little exaggerated, gives a fair idea of the nature and extent of the "shattering" alluded to



Since the C line was not similarly affected it is hardly possible to attribute this breaking up of F to cyclonic motions in the gas from which the light emanates, and it becomes very difficult to imagine a cause which can thus disturb a single line of the spectrum by itself. Possibly this appearance may be the result of local absorptions acting upon a line greatly widened by increase of pressure or temperature.

It continued unchanged for more than half an hour, and until the sun passed out of sight behind a building. The observations were made with the 5 prism spectroscope.

Hanover, N. H., May 20th, 1870.

Reproduction of the Oxide of Iron employed in gas purifiers, by means of steam. C. Mène, in a paper on the above topic, which is noticed in the *Chemical News*, describes a new mode of operation, which is at once simple and, to all appearances, complete. It may prove to be of inestimable practical importance. The process described, is in use in the Lyons Gas works, and is as follows: The iron to be revivified is taken from the purifiers, loaded with its sulphur, and placed in a tightly closing iron reservoir, into which steam is admitted by a pipe emerging in its lower portion.

Coming into contact with the sulphide, the steam is decomposed, its hydrogen goes to the sulphur, and its oxygen regenerates the iron. Sulphuretted hydrogen, the gaseous product of the action, is carried off by an escape pipe leading to the chimney of the furnace.

The mode at present employed whenever oxide of iron is used as the purifier is to expose it over considerable space to the gradual action of the air: The new method in its convenience and time-saving bids fair to come into universal favor.

Bibliographical Notices.

Die Spectralanalyse in ihrer Anwendung auf die Staffe der Erde und die Natur der Himmelskörper. Gemeinfasslich dargestellt, von Dr. H. Schellen, Director der Realschule I. O., zu Cöln. Braunschweig. Druck und Verlag von George Westermann, 1870.

The Spectrum Analysis, in its Application to the Matter of the Earth, and to the Elucidation of the Nature of the Heavenly Bodies. A popular treatise, by Dr. H. Schellen, Director of the Realschule I. O., in Cologne. Published by George Westermann, Brunswick, 1870.

This is undoubtedly the most thorough work on the subject of Spectrum Analysis which has yet appeared.

Some 50 pages are, in the first place, devoted to the sources of light, such as the oxohydrogen, the magnesium and various sorts of electric lights as well as the common flames and Bunsen burners, The nature of light as illustrated by the more readily studied phenomena of sound and the general laws of reflection, refraction and dispersion, are then discussed in some 50 more pages.

The spectroscope is then fully described and illustrated with the phenomena of optical phosphoresence and selective absorption.

This portion of the work occupies some 70 pages, and is full of new valuable matter, some of which we shall presently describe more in detail.

Next to this comes the sun spectrum and the Fraunhofer lines, with the discoveries of Bunsen and Kirchhoff, and the observations of Janssen and others as to the aqueous lines. A full discussion of the phenomena of sun spots then follows profusely illustrated with many new engravings admirably executed. This takes us about 50 pages further.

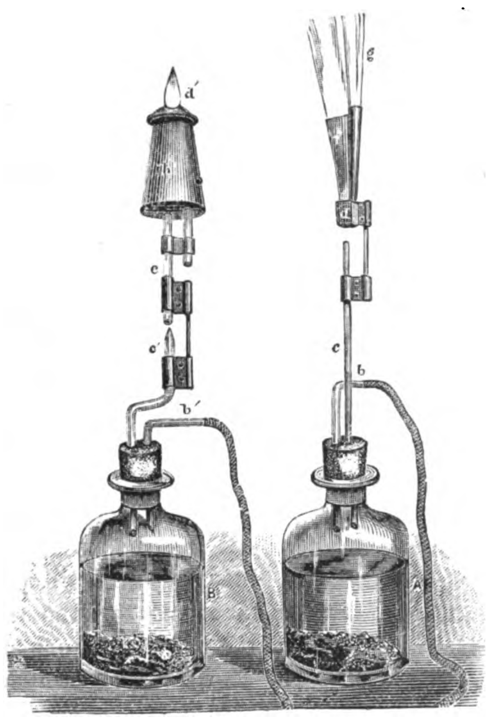
The solar prominences next receive attention, and here we have a full account of the observations of De la Rue in 1860, with copies of his photograph and of all the similar work accomplished in 1868 by Vogel, Tennant, Janssen and others, as also the discoveries of Lockyer and Huggins.

Here also are a vast number of the most interesting illustrations, and nearly 100 pages are devoted to this subject.

The next hundred pages are devoted to a full description of instruments, methods, and results in connection with the study of stellar, nebular, cometary and meteoric spectra, and lastly we find a few pages on the spectra of lightning and the aurora.

The entire work is eminently characterized by that thoroughness which is the eminent merit of German treatises, and nothing is alluded to which is not fully explained.

Thus we were much annoyed to find in Roscoe's otherwise excellent book on this same subject a figure of Bunsen's apparatus for illustrating selective absorption, which was neither self-explanatory nor accompanied by any description. Here, however, we find a much clearer figure supplemented with a full account, from which the action of this curious and ingenious arrangement becomes at once manifest.



This is of so much interest that we have reproduced the figure on a smaller scale, and here give it with a sufficient description. A and B are two flasks containing zinc and hydrochloric acid mixed with a solution of salt. The hydrogen evolved is thus filled with a fine spray of salt. Pipes *b* and *b′* lead into these flasks the ordinary illuminating gas which mingles with the salt-charged hydrogen and escapes by pipes *c* and *c′*, each of which, by a sort of locomotive exhaust action, carries with it a large amount of air into the pipe above, from which the mixture passes into burners, the first of which, *f*, is of a scoop shape, and makes a strong flame which is to serve as the background to the other. By adjustment of the relative amounts of hydrocarbon gas, and hydrogen, the flame, *g*, is

made very intense while *d* is rendered as cool as possible. By this means the light from *g* is well absorbed in traversing *d* and this later appears as a black flame when seen against *g* as a background.

Portraits of Bunsen, Kirchhoff, Huggins and Secchi in the shape of excellent woodcut plates are interspersed through the book which has, besides two colored plates, and 158 woodcut illustrations, a few of which we have seen before in some Hachett's publications, but the greater portion are entirely new and of great value.

The Andes and the Amazon, by Prof. James Orton. New York: Harper & Bros., 1870.

In former years any literary hack, who wielded a ready pen, might presume to write a book of travels and be favorably spoken of by the other hacks who criticised him. Provided he talked humorously enough of a wrangle with the postillion, described vivaciously the woe-begone appearance of his fellow-voyagers in a fall of rain, and now and then displayed fine writing about landscape beauties, his book, being no better nor worse than a hundred preceding, had its three days of birth, popularity and oblivion. But now, the idea is gaining ground that he who undertakes to describe something foreign, should possess some peculiar fitness for the task. If his mission is to write about art, it is not sufficient pleasantly to narrate his feelings and fancies on viewing paintings and statues, but to demonstrate that he has arrived, through years of study and comparison, to a knowledge exact, circumstantial and complete. And the same remark is or ought to be true of any author who dares to treat upon the literature or manners, the social condition, laws or government of the countries through which he travels. So far as the natural history of *terræ ignotæ* is concerned, we are already rich in works of lasting value, and are yearly growing richer. What powers of observation and experiment, what stores of previously acquired knowledge, have contributed to the composition of the writings of Humboldt, of Tyndall's Glaciers, Lyell's Travels in North America, G. Rose's Reise nach d. Ural, and Darwin's Cruise in the Beagle. We welcome Professor Orton's "Andes and the Amazon" as a valuable addition to this solid literature. He gives, for the benefit of future voyagers, an account of the routes, modes, perils, pleasures and expenses of a journey across the continent of South America. A minute catalogue is furnished

of the vegetable productions, which are valuable for food, of the extent to which they have been and could be cultivated, and of the amount reported. Whenever opportunity presents, attention is called to the many new sources of riches and trade afforded by the natural wealth of these fruitful countries. He has carefully noted the numbers and kinds of wild and domesticated animals: the insects remarkable for their size, beauty or destructiveness, are described. An attempt is made to correct the commonly received but erroneous notion concerning the kind and abundance of reptilian life in South America. As much of the ichthyology of the valley of the Amazon is given as will convey to the general reader a proper appreciation of this pre-eminently ichthyic region. Where the dampness and heat of the atmosphere, and the rankness of the soil, originate a redundancy of flowers and fruit, it is proper that the botany of the country should occupy the prominent place which is accorded it. Following the map of the Amazon, compiled from many sources, and corrected by the personal observations of Professor Orton, we are made acquainted with the curious topography of this network of mighty rivers and innumerable natural canals. The description of the geography and climatology is founded upon a multitude of careful instrumental determinations. It was impossible, when so little of the entire field has been examined, to give any account of the geology of the country as a whole, but the little that is given is very interesting. By the discovery of marine shells, Professor Orton has established that the great bed of unstratified clay, which overspreads a large part of the Amazon valley, and whose origin has been controverted, is marine. In view of the probability that a few decades will witness the extinction of the multitude of Indian tribes now occupying South America, the reader will find the information concerning the language, affinities and customs of these savage nations, of great interest.

To the merchant, desirous of opening new avenues of lucrative traffic, to the naturalist, anxious to acquire a general knowledge of these little known countries, and to the general reader whose curiosity extends to something deeper than a superficial acquaintance with foreign lands, we warmly commend this very entertaining and instructive book.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, May 18th, 1870.

The meeting was called to order, with Mr. Coleman Sellers, President, in the chair. The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and stated that at their stated meeting, May 11th inst., the following members, on their application in writing, were constituted the Optical Section of the Institute, viz.: Messrs. D. Shepperd Holman, Edward F. Moody, Andrew M. Spangler, Samuel Sartain, Coleman Sellers, Henry Morton, Lemuel J. Deal, Thomas W. Starr, R. Egglesfield Griffith, William H. Walmsley, Hector Orr, Isaac Norris, Jr.

Donations to the Library were reported from the Royal Astronomical Society, the Royal Geographical Society, the Statistical Society, the Society of Arts, London, and the Steam Users Association, Manchester, England; Thomas Oldham, Superintendent of the Geological Survey of India and of the Museum of Geology, Calcutta, India; Prof. J. H. C. Coffin, Superintendent of the American Ephemeris and Nautical Almanac, and Hon. William D. Kelley, H. R., Washington, D. C.; the Peabody Institute, Baltimore, Md.; the Young Men's Association, Buffalo, and Verplank Colvin, Esq., Albany, New York; Dr. George W. Norris; the Historical Society of Pennsylvania, A. W. Blackburn, Fire Marshal of the City of Philadelphia, and the Schuylkill Navigation Company, Philadelphia.

The various Standing Committees reported their minutes. The Secretary read his report on Novelties in Science and the Mechanic Arts, in the course of which some remarks were made by Mr. J. E. Mitchell on the use of black diamond in stone-cutting and boring.

In answer to a question by a member, the President stated that a committee had been appointed by the Board of Managers to confer with the city authorities and the National Congress with reference to the location of the centennial celebration of our National Anniversary in this city, and that this committee had already been repeatedly in conference with the other bodies on this subject. Nothing definite, however, had been reached as yet, and much would depend upon the exertion and liberality of our citizens at large. On motion, the meeting was then adjourned.

HENRY MORTON, *Secretary.*

OPTICAL SECTION.

Proceedings of the Stated Meeting, June 1st, 1870.

At the meeting of the Section, Mr. Thomas W. Starr offered a number of preparations, mainly of insects. Amongst them was an interesting series of parasites, which attracted deserved notice. We enumerate those of the rat and ground mole; the last, like the animal which bears it, with rudimentary organs of sight. A transverse section of nine straws, fitted one within the other, made a curious specimen, and rendered the stem structure very apparent.

Next followed a number of excellent preparations by Mr. W. H. Walmsley. We select for notice, some leaflets of aspidium, adiantum and other ferns, the sori, spores and chlorophyl granules of which were rendered distinctly visible. Sections of various stems illustrating structural differences; one specimen (that of mahogany) showing the ends of the medullary rays, while in that of the blackberry the vascular portion of the stem was deeply stained, and the pith-cells free from color. [The preparation was made with the aid of a coloring solution.] An injected specimen of sheep's kidney, showing the tubuli and Malphigian corpuscles, was received with cordial approbation.

An interesting feature of the meeting was the exhibition of living specimens in an ingenious modification of the "animalcule cage," contrived by D. Shepperd Holman, a member of the Section. In this the composite slide is altogeter avoided, and a generally much superior result obtained by a simpler method than the ordinary one. The slide consists of a glass plate of the ordinary kind, with its upper surface ground, and with one or any desirable number of saucer-shaped depressions ground and polished in its central portion. In each of these the liquid containing the animalculæ is dropped until they are completely full, and the usual glass cover placed accurately over them, taking care to avoid the introduction of air-bubbles. When the excess of liquid which has been forced out from beneath the cover, is wiped away, the simple adhesion between the liquid and the cover is amply sufficient to retain the latter in its place, thus rendering the use of varnish or other adhesives unnecessary. The lower surface of the cover, beyond the edge of the circular pool, is never absolutely in contact with the slide, and there is thus furnished a capillary space through which

the liquid slowly passes outwards and evaporates from the exposed edge. The rapidity of this action will depend much upon the temperature and moisture of the air, but in general manifests itself very soon. The pressure brought upon the cover with the finger, in holding it while wiping off the water, in addition, slightly inflects it and expells a small amount of water, which causes a relief of internal pressure when the finger is removed, through the elasticity of the glass, which makes it recover its position, and the capillary action of the water which prevents the inflow of air. There is thus created beneath the cover a partial vacuum, and the pressure from without is added to the adhesion of the liquid as a factor to fasten down the cover more firmly than before. In time the cover shows a perceptible concavity, which increases until it finally breaks. This is, however, no obstacle to the efficiency of the "cage," as it never happens until some days have passed, and preparations of this kind are rarely needed for more than a few hours.

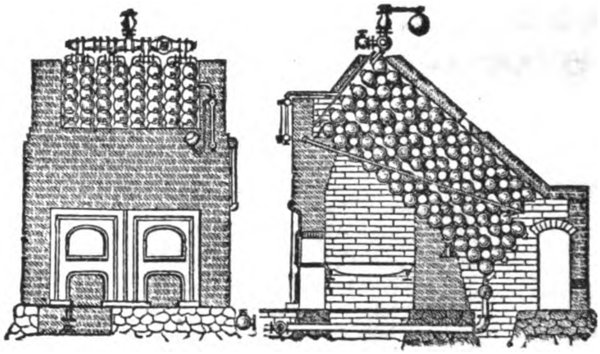
Aside from the simplicity of this arrangement, we should not forget to mention another peculiarity it possesses which renders it highly suitable for showing living specimens. The latter, it seems, from some cause, prefer the outer and shallow edge of the pool, in which to perform their evolutions and circle slowly around the rim, so that when once adjusted in the microscope they remain constantly in the field, by which the very troublesome annoyance of repeated hunting for them is avoided.

W. H. Wahl, *Recorder.*

A New Paper Reagent.—From *Cosmos*, we obtain the information that M. Böttger has produced a new test-paper, which is highly sensitive towards the alkalies and alkaline earths. The reagent is a magnificent coloring matter, obtained from the leaves of an exotic plant, (*Coleus Verschaffelti*,) upon digestion for 24 hours, with absolute alcohol, to which a few drops of sulphuric acid has been added. The paper is prepared for use by the usual process.

The color is a splendid red, which passes more or less rapidly into a fine shade of green, by the action of the alkalies or the alkaline earths. It is far more sensitive than either turnsol or turmeric; it is unaffected by carbonic acid, and will indicate the presence of the least traces of the carbonates of the alkaline earths in natural waters. A moistened strip of the paper, when held at the opening of a gas jet, immediately assumes a green color, from the effect of the ammonia.

HARRISON STEAM BOILER.



UNION SUGAR REFINERY,
Charlestown, Mass., January 21, 1869.

Mr JOSEPH HARRISON, Jr.

Sir:—In my last communication to you in regard to your six fifty-horse power steam boilers, I promised to give you, at a future time, the exact amount of saving in fuel.

I am pleased to be able to do so now, as I kept a very close and accurate account of the fuel used from December, 1867, to December, 1868, to compare your boilers with the old ones, which we took out in September, 1867.

The amount of raw sugar we refined during that time was larger than ever before. The steam pressure was always kept over fifty pounds, and we were therefore enabled to do more work in a shorter time with the same machinery and apparatus than with our old steam boilers, in which the pressure, at times, could not be kept up higher than twenty to thirty pounds.

The actual saving in fuel, during this time, was one thousand and seventy-one tons of coal.

Yours truly,

GUSTAVUS JASPER, Superintendent.

Worcester, Mass., February 1, 1869.

JOSEPH HARRISON, Jr.

Dear Sir:—After using one of your thirty-one horse power boilers sixteen months, it gives me great pleasure to say that it has proved, in every particular, entirely satisfactory. I have had many opportunities to recommend it, which I have done with pleasure. For economy in fuel, it excels all boilers in use. I can raise steam in shorter time than in any boiler I have ever seen; and would cheerfully recommend it as the cheapest, safest, and most economical boiler ever in use.

Very respectfully yours,

A. N. WHEELER.

OFFICE OF THE GRANITE STATE MILLS,
Newport, N. H., February 1, 1869.

JOSEPH HARRISON, Jr., Esq.

Dear Sir:—Yours of January 9th, asking our opinion of the Harrison Boiler, is at hand. We have had your boiler in use fifteen months, and it gives us perfect satisfaction in quickness of raising steam, and the cheapness of running it, as compared with the old-fashioned boilers. Our boiler does not yet leak a drop, and we do not believe it ever will; and last, though not least, our workmen about it do not feel obliged to get their lives insured.

Yours truly,

COFFIN & NOURSE.

Concord, N. H., February 8, 1869.

JOSEPH HARRISON, Jr., Philadelphia, Pa.

Dear Sir:—Your favor of January 9th came duly to hand. The 62½ horse power boiler, which we had of you in October, has, from the time we commenced its use, until now, given perfect satisfaction, and we can see no reason why it should not continue to do so. It is the only boiler (and we have had a variety of kinds,) that suited us from the first. We save fuel, are troubled with no leakage, and feel safe in using it. We can only say that it meets more than our expectations.

Truly yours,

ABBOT, DOWNING & CO.

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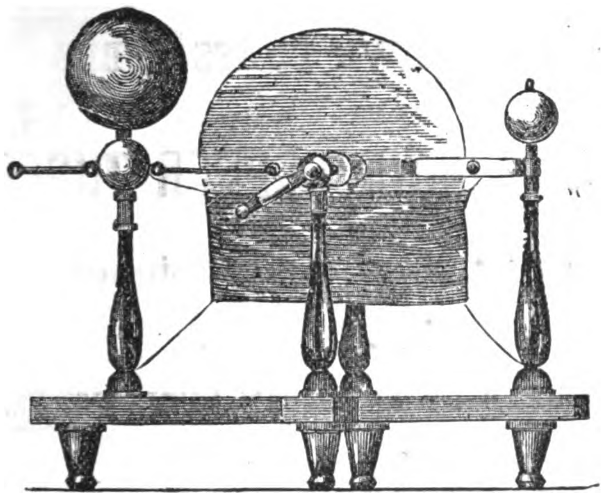

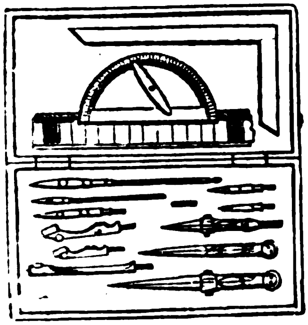

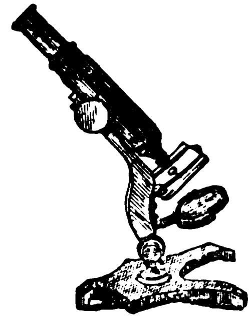

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FRANKLIN INSTITUTE.

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EDITORS

PROF. HENRY MORTON, PH.D.

AND

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ASSISTED BY THE COMMITTEE ON PUBLICATIONS.

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LX.] AUGUST, 1870. [No. 2.

EDITORIAL.

ITEMS AND NOVELTIES

Remarks on the Progress in Wood-Working Machinery and the Manufacture of Iron in England.—By Robert Briggs, C. E. We insert in this place the following abstract of remarks made by Mr. Briggs at the last meeting of the Institute, in order that they may be more likely to reach the eye of our readers, who would otherwise lose a very important part of the present number.—ED.

At the request of the President, Mr. Robert Briggs gave an account of various matters, interesting to engineers, which had come prominently before him during a six month's visit to Europe, from which he had just returned. He first alluded to the uniform courtesy and liberality with which American engineers were received and introduced to all that was worthy of notice, professionally, by their brethren on the other side of the water. He

described the state of progress at much length, saying that both in civil and mechanical engineering a great depression has accompanied the failures incident to the limited liability crisis. Civil engineering, the past three or four years, had not witnessed the expansion of field or novelty of extension which, prior to that time, had accompanied a similar period.

The most evident improvement in the mechanical branch of engineering was in the wood-working machinery, which, under the call to be used upon harder woods than with us, had been far more substantially constructed, and, as a result, finally had proved more effective for all kinds of wood than the examples from which the English had copied. He stated that the English were slow to use our labor-saving machinery, but when they did adopt those improvements which dear labor had taught us, they added strength and solidity at small cost to themselves, and generally obtained better results than we did. He spoke at much length upon the progress in the manufacture of iron, which, the past year, has received a new impetus in Great Britain, but thought that while the average of English furnaces or mills was about equal to our average, there were points of excellence in our best mills, especially, which they had not reached. On the other hand, their best furnaces, in completeness of construction, magnitude, and especially in result, were far beyond our's. The Bessemer process, also, had received a successful and practical development which we had by no means attained.

He thought the most valuable improvement in the processes of the manufacture of iron, since the Bessemer introduction, was the successful use of Cowper's regenerative (Sieman's) stoves for heating the blast. These, after five years of trial and improvement, in detail had been put in an eminently satisfactory form by Messrs. Cochrane, at Ormsby, Middlesbro' on Tees.

Messrs. Cochrane had permitted Mr. E. A. Cowper, the inventor, to state publicly that "There was a saving of 4 cwt. of coke per ton of iron produced, by the use of the Cowper stoves for heating the blast, when compared with good cast iron pipe stoves, and the saving was still more with the ordinary pipe stoves. With a large furnace, producing 475 tons per week, the first cost of these stoves was somewhat less than the cost of pipe stoves, while the expense of working was less, so that the profit, taking everything into account, was estimated to amount to £4,162 a year."

The system required that each stove, or pair of stoves, should be composed of two similar parts, each of which consisted of a cylindrical wrought iron casing, say 20 feet in diameter by 25 feet high, lined with fire-brick, and covered in by a fire-brick dome, the whole to be air-tight, to carry the pressure of the blast; a central shaft of fire-brick, some 2 feet 6 inches or 3 feet of internal diameter extended to within a few feet of the dome. In the annular space between this shaft and the sides of the case was built a reticulation of passages, or pipe-like openings, of 4½ inches square, which filled the annular space from the top of the shaft to within a foot or so of the bottom, where a chamber for collecting these openings into one duct was formed.

The pipe-like openings thus became about twenty feet in length. They were built of ordinary split fire-brick, and the fire-brick were not laid so as to form a series of square tubes, but each course of brick was laid to overhang or drop back from the one below, and thus present that kind of obstacle to free passage as would ensure the circulation of air in the rough tubes. At the same time the silicious dust could, with facility, be swept out by a brush whenever it was necessary.

The central flue was connected by valves to the gas ducts from the tunnel-head, and another valve admitted air to burn the gas, the flame from which rose up against the dome; the heated products of combustion were distributed and passed downwards through the tubular passages, and were carried off through the chamber at the bottom, and yet another valve, into the chimney. The products of combustion had a temperature of about 3,000°. In the course of a few hours the entire mass of internal brickwork would be heated from the top downwards, a good red heat penetrating nearly to the bottom, and the stove would then be ready to heat a volume of blast to 1,400° or 1,500°.

All the valves heretofore mentioned would now be closed, and two others, one leading from the blowing-engine to the annular chamber at the bottom, and the other from the central shaft to the tuyères would be opened, and the stove would then supply heat to the blast, absorbing it from the bottom upwards, with little difference of resulting temperature, until, during the time needed to heat up the companion-stove, the bricks will be robbed of heat to within a few feet of the top. The falling off of temperature at the last part of the process is stated not to be over 100° to 300°, and is

found productive of no injury to the result. Mr. Briggs expressed the opinion that the improvement was especially applicable to iron making in America, but that the blast-pipes needed to be of wrought iron, and lined with fire-brick.

Mr. Briggs further alluded to the processes of gas-making and purification, to which he had given much attention. But, he said, the subject was so technical and especial, that whilst he had found great difference in the construction and operation of works, he could not offer his information to the audience with any satisfaction. It is understood that he will avail himself of some opportunity to publish his results of investigation elsewhere at an early day. He further spent much time, to the gratification of the audience, in describing the street improvements of Paris, which he considered to be the solution of the question of the city of the nineteenth century, for the accommodation of the pleasure and commercial traveling community.

He thought the introduction of superior means of transportation for passengers and merchandise by the railways and ocean steam navigation had made a change in the requirements for the entertainment, accommodation and convenience of visitors and citizens of the metropolitan cities, which made re-planning and reconstruction inevitable.

Mr. Briggs also drew attention to the fact that a fine series of plates, in three volumes, representing the new edifices constructed in Paris in the course of these improvements, had been presented to the library of the Institute by Mr. William Sellers. The remarks were listened to with great interest, and were highly applauded.

Diamond Rock-Boring Machines.—In the June number of the *Journal*, a mention was made of the successful application of diamond tools for cutting purposes. A notice here of a more extended and perhaps more important practical introduction of the same material may not prove uninteresting to some of our readers. We refer to the "Diamond Rock-Boring Machine," for the account of which we are indebted to *Engineering*, (Vol. IX., No. 232.)

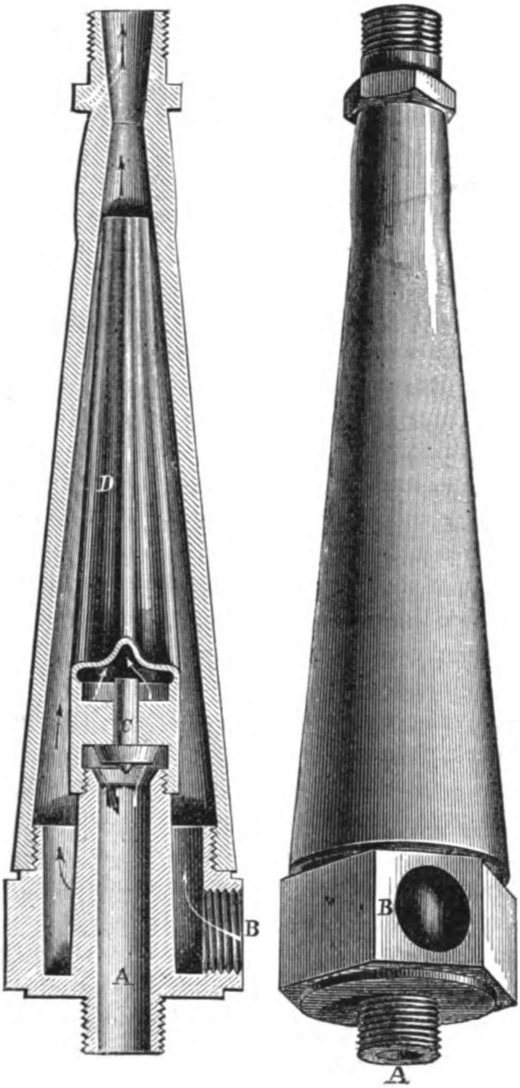
The use of the diamond in machine tunnelling is by no means a novelty; but the signal success in the case to be mentioned may be considered as placing it above the level of a mere experiment in this direction.

The machine is being used by the Croessor United Slate Com-

pany (in Wales) in constructing a new and difficult shaft. The motive power is an engine working with compressed air. Several boring tools are used simultaneously, which by simple appliances are so mounted as to admit of being "angled" in any desirable direction. The drills are made hollow, in order that when at work, a constant stream of water may flow through and about them, to act as a lubricator, and to prevent the heating of the tools by friction. The work of opening the shaft progresses with more than twice the rapidity at which it could be done by miners, while the expense, though greater than that of hand labor, is in view of the greater work performed not proportionately increased. Thus far 180 yards of tunnel have been successfully opened, and the work progresses at the average rate of 4 yards per week, or not far from 20 yards per month; the shaft being 8 feet high and 10 feet broad through hard slates which as usual are abundantly penetrated with veins of harder quartz. "The advantages of the diamond system," according to our informant, all result from employing a rotary movement instead of percussion, which enables a machine of extremely simple character to be employed, and one which can hardly get out of order; a point of value which can hardly be over-estimated, when it has to be put in the hands of miners, working in the wet and dirt of a tunnel. The drills are worked by a minimum number of men, since when once started they need no attention until the holes are down. There is a considerable economy of power as the air being used in the cylinder of an ordinary engine can be expanded as much as may be considered advisable, which, with a percussive drill, is not the case, because the blow would be deadened, besides involving an inconvenient increase in the size of the working parts. Last but not least, the shortness of the drill enables holes to be put in any direction, even in positions that miners could not conveniently reach. * * * * In its performance thus far it has amply shown that the system of non percussive drilling is decidedly a most advantageous one, as the machine is subject to very little wear and tear."

Steam Water Heater.—Patented by Wm. B. Mack. This instrument is a conveniently adapted contrivance to heat water by means of steam, and is especially intended to be used where large quantities of water at any temperature to 212° F. are in constant demand. It may therefore be useful to brewers, dyers, soap boilers

and others to examine into its claims to efficiency for this special purpose. The accompanying illustration will explain its construction and working:—The figure in cross-section shows an outer cylinder of brass, which is fitted to a basal piece having a central channel A, and an opening at B, which last communicates freely with the cylinder's interior. Within the cylinder and upon the basal piece, a hollow tube, D, of thin sheet-metal, and furnished with four longitudinal grooves or depressions, is mounted; and its interior communicates, with the passage A of the base. At the point of juncture of the latter with the tube D, is a check valve C. An annular space between the inner walls of the cylinder, and the exterior of D is thus entirely shut off from communication with the passage A, and its prolongation within D, except at the upper extremity of the instrument, where the latter ends and the contents of both parts mingle.



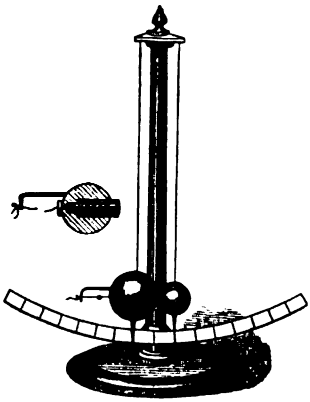
An exterior view of the instrument is beside the sectional one, with the openings at A and B visible

The operation of the contrivance is as follows:—An adjustment from the boiler furnishing the steam supply, attaches by the screw-thread of the opening B, while the water service is placed in connection with A. By the two openings water and steam are now admitted simultaneously. The former passes into A, lifts the valve C, and enters the tube D. The latter rushes into the annular space surrounding the central tubes. The tube D being of thin sheet-metal, rapidly conducts to the cold water within it, the superior heat of the steam without, the longitudinal groovings in its circumference being a simple device to increase the extent of conducting surface. It is claimed that the abstraction of heat is so complete that all, or the greater part of the steam admitted, emerges into the neck of the instrument, robbed of its latent force, as water; and mingling there with the liquid to which it has imparted its heat, they pass out together, through the common outlet into the reservoir appointed to receive them. The check valve C prevents any reversion of the flow, from whatever cause such an accident might originate. It will be observed that the contrivance of Mr. Mack differs from the methods of steam water heating in general use in the essential particular that, in place of direct introduction, he substitute a heat abstractor in the form of a large and good conducting medium between the steam and water, keeping them apart until the action is finished.

By regulating the influx of steam or water, any desirable temperature within the well-known limits can be attained; and one of the advantages claimed by the inventor is that his instrument furnishes a simple method of accomplishing this desideratum to a nicety. Being entirely noiseless, owing to the keeping apart of the materials involved in the work, it obviates a highly unpleasant and even dangerous peculiarity attendant upon the usual system of direct introduction of the steam; we refer to the jarring and thumping, with which all acquainted with the procedure will be familiar. In a variety of applications, too, which have been made of it, an economy in time is claimed. We understand that it has been considerably introduced into breweries; by several institutions (prisons, &c.,) for bathing purposes, and by the New York Central Railroad, for the washing out and refilling with heated water, of their engines. The heaters deliver steam varying from ½ inch to 2 inches in diameter, and are made from 11 to 40 inches in length.

Illustrations of Momentum.—No subject in physics has been so generally misunderstood and so inaccurately explained in element-

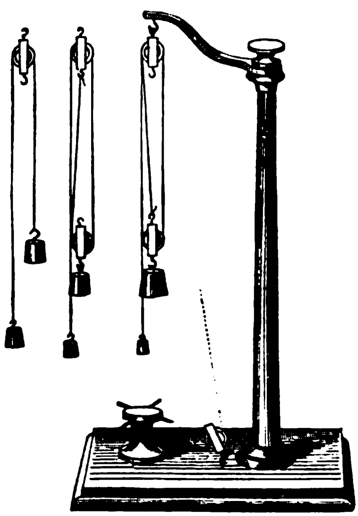
ary works as that of momentum and the related subject inertia. We would direct the attention of our readers to Vol. XLIV., page 120, and Vol. XLIV., page 197, of this *Journal*, should they desire proof of this assertion as they will there find the prevailing definitions quoted and discussed.*



We are, therefore, glad to see in Mr. E. S. Ritchie's new catalogue the figure of a piece of apparatus (shown in the accompanying cut) by means of which many of the false impressions may be corrected by practical demonstration and the true relations of the subjects established in a similar manner.

Of the two suspended balls one contains a spring hammer liberated by burning a thread, the other ball is of a definitely proportional weight to the first, several of different weights being provided. By a study of the relative effects of the hammer in moving its own and the other ball, the fundamental conditions of the subject may be fully elucidated.

Illustration of Pulleys.—We notice in Mr Ritchie's new catalogue a very compact and convenient arrangement for the illustration of the action of pulleys. Besides its small bulk and the ease of transportation, this construction has the advantage of bringing before a class one combination at a time and thus avoiding the confusion likely to be produced in the eye and mind by a row of similar and yet various conformations of cards and blocks. The cut illustrates only a few of the combinations belonging to the set, which are packed in boxes and attached in succession to the same support.



* See also Vol. LVI., page 344.

Compressibility of Gases under high pressure.—L. Cailletet. We find in the *Chemical News* a notice of a paper on the above-named subject, which we give in full. "The author has studied the variation of compression of air and hydrogen between 1 and 800 atmospheres. Up to 80 atmospheres pressure, air is more compressed than it should be if it followed the law of Mariotte, and at 680 atmospheres it only occupies two-thirds of the space, which it ought to do theoretically. The method by which the author is enabled to measure the volumes occupied by a gas in an opaque apparatus is very simple. The glass tube is enclosed in an iron one, the former containing the gas, is lightly gilt. The mercury which serves to transmit the pressure whitens the gold, leaving a well defined mark upon it after the pressure ceases."

Steam Filter Pump.—By Dr. J. Walz.—There are many locations in which the Bunsen filter pump cannot be employed on account of a deficiency in the water supply. For such cases a plan has been devised by Dr. Walz of New York, Editor of the *Manufacturers' Review* and *Industrial Record*, which is described in that journal, and has been proved in practice to be efficient.

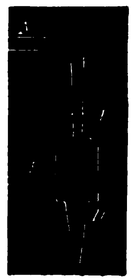


Fig. 1 shows the outline section of the most important part of the apparatus. A is a tube supplied with steam from a flask or boiler; E is connected with the exhaust of the filter. By the action of the steam jet identical with that known as the "exhaust" in a locomotive, a vacuum is produced in B C D. By sliding the tube A back and forward in the cork B, an adjustment can be given to the outlet within D, so as to secure the best effect.

By reference to Vol. LVI., p. 130 of this *Journal*, it will be seen that the conditions of best effect here are identical with those in the inner nozzle of the Giffard Injector when it is starting its water supply from a lower level, and no doubt the proportions found most efficient in that instrument will prove also in this.

Industrial Exposition.—We would call the attention of manufacturers, artists, inventors and others, who would be likely to be interested, to the fact that an exposition of art and mechanism of the most general character will be held at Cincinnati, under the auspices of the Chamber of Commerce, the Board of Trade and the Ohio Mechanics' Institute of that city, to commence on Wednesday, September 15th. A commodius exhibition building will be erected

for the purpose, and liberal inducements are offered to exhibitors, both with regard to number and quality of awards and premiums, and in judicious arrangements with railroad companies and others, in the way of increased facilities for and deductions in the rates of transportation.

Those desirous of availing themselves of the advantages of the exposition, can obtain all necessary information, by addressing themselves to the Secretary of the Cincinnati Industrial Exposition.

Observations on Jupiter.—By Prof. Mayer and Mr. Gledhill. The well-known English astronomer, the Rev. Thomas W. Webb, F. R. A. S., in a recent letter to Prof. Mayer, says: "You will see that I was so unfortunate as entirely to miss the very curious ellipse on Jupiter, observed by yourself, and also, as you will have seen in the *Astronomical Register*, by Mr. Gledhill in England, where no one else seems to have noticed it."

Mr. Gledhill's paper is in the April number of the *Astronomical Register*. His drawing and Prof. Mayer's are remarkably alike. Mr. G. used a 9⅓ inch Cooke refractor. Generally the full aperture was used. The usual working power was 240.

As the observations of Prof. Mayer were made with a refractor of 6 inches aperture, the quantity of light received in the two telescopes was as 87 to 36, and this speaks well for the excellence of the 6-inch glass of Mr. Alvan Clark.

CHEMICAL ITEMS.—Anthracene and Alizarine.—Graebe and Liebermann have published a resumé of their investigations during the past two years upon anthracene and alizarine and their derivatives.* Our first knowledge of anthracene came from an investigation, made by Dumas and Laurent in the year 1832, in which they discovered a hydrocarbon of especial interest in the denser part of coal tar. They obtained for it the formula $C_{15}\ H_{12}$, and since this is 1½ as high as that of naphthaline, they named their hydrocarbon paranaphthaline. Later, Laurent gave it the name anthracene, because a great number of hydrocarbons, polymers of naphthaline, may exist in coal tar, to all of which the common term paranaphthaline might properly be applied. In 1857, Fritzsche described a hydrocarbon of high boiling point arising from tar, of the constitution $C_{14}\ H_{10}$. He drew attention to the fact that this compound, in many respects, was similar to Laurent's anthracene. By the investigations of other chemists, this identity has been fully established.

* Ann. d. Chem. u. Pharm., 1870.

Anderson and Berthollet have made known in full in what manner pure anthracene may be obtained from the dense portions of tar by repeated distillation, pressure, recrystillization from benzine and sublimation. But anthracene in tolerable purity will soon be an article of commerce. In this case, if the anthracene, supposing it to have been already freed from oil, has not its proper melting point of 210° to 213° it must be recrystallized from benzine until it melts at this temperature. The anthracene thus obtained, is in crystals, to which a bright yellow coloration so tenaciously clings that they cannot be rendered fully white by recrystallization. They can be freed of this yellow tint, however, by two methods—by sublimation at the lowest possible temperature and subsequent washing with ether; or, by bleaching a solution of anthracene in hot benzine by direct sunlight. In the last case the anthracene separates on cooling in colorless crystals, of a superb blue fluorescence. This last method has the disadvantage that the anthracene can easily become mixed paranthracene. These crystals are tabular, smaller or larger according to the degree of purity, and belong to the monoclinic system. If colored at all yellow—the coloring substance is chrysogene—the beautiful blue fluorescence above alluded to, is not seen upon them. Anthracene is soluble with difficulty in alcohol and ether, easily in boiling benzine. It melts at 213°, and distills at 360°. Sublimation, however, in small leaves takes place before the temperature has reached the melting point. The behavior of anthracene towards reducing agents, towards bromine, chlorine and oxidizing substances is given in great detail. The same chemists have effected the reduction of alizarine, by means of a great excess of zinc filings, in a combustion tube. The hydrocarbon thus obtained agrees in all its properties with anthracene.

Silvering of Glass.—The proportions given below have proven to be the best for the preparation of silvered mirrors according to the process of J. v. Liebig.* The silvering fluid is obtained by the mixture of a silver solution with a reducing liquid. The silver solution is prepared from argentic nitrate, an ammoniacal salt and soda lye. One part argentic nitrate is dissolved in 10 parts water. The ammoniacal solution is procured by neutralizing nitric acid, free from chlorine, with ammonic sesquicarbonate (to 30 parts acid of density 1·29, about 14 parts sesquicarbonate), and diluting this solu-

Chem. Centrall Blatt. [3], 1.

tion to density 1·115. Or 242 grms. ammonic sulphate are dissolved in water and diluted to 1·2 c.c. The soda lye must be free from chlorine and have a density of 1·05; 140 volumes of the first, 100 volumes of the second, and 750 volumes of the last, give the silver solution. If ammonic sulphate be used, its solution must be poured into the argentic nitrate solution and then soda lye added in small portions. The liquid is turbid and requires about three days to clear. For reducing liquid a solution of inverted sugar and sodio-cupric acetate is used. The sugar solution is obtained by dissolving 50 grms. white candy sugar in water to a thin syrup, then adding 3·1 grms. acetic acid, keeping at the boiling point for an hour and diluting to 500 c.c. The copper solution is prepared by adding soda to 2·857 grms. dry cupric acetate, which has been covered by water, until the blue powder has dissolved. The solution is diluted to 500 c.c.: 1 volume of sugar and 1 volume of copper, give the reducing liquid. The silvering fluid is made by mixture of 50 volumes silver solution, 10 volumes reducing liquid and 250 to 300 volumes water. The silver solution is diluted with water, the reducing liquid added, and then the bath is filled. In winter, warm water is used, so that the fluid has a temperature of 20° to 28°. When the glasses are plane, two are placed in contact, and the pair placed vertical in the bath. Curved glasses must come in contact with the fluid only upon their upper surfaces. The silver coating thus obtained should be bluish-transparent and resplendent, and must adhere so firmly as not to be rubbed off by polishing. The cost does not exceed that of the commonest looking glasses. The amount of silvering fluid required for a square metre is only 3 to 3·5 grms.

Editorial Correspondence.

CHEMICAL THEORIES.

Editors of the Journal of the Franklin Institute.

GENTLEMEN:—In the June number of the *Journal* is a communication from Prof. Albert R. Leeds, in which he says, in regard to the so-called dualistic and unitary theories in chemistry: "The few who cling to their ancient beliefs have ceased to defend them, and

only plead the inaptitude of old age, or the bias of early education, in defence of their loyalty. But now that the unitary theory has prevailed, it is intolerable," &c.

Inasmuch as some chemists not without note, including Bunsen, Berthelot, Fremy, Bloxam, Taylor and Fresenius, still "cling to their ancient beliefs," and as a very good defence of the same may be found in Brande and Taylor's Chemistry, or in Bloxam's latest edition, it seems that the subject is fairly open to discussion.

The *facts* of chemistry are ascertained by experiment: no theory can alter them in the least. Theory is merely a convenient method of arranging the facts and aiding the memory. We have two theories in electricity, the one fluid and two fluid theory. Either is convenient in explaining the phenomena; yet I think that no one believes, at the present day, that electricity is a fluid. The language is retained, for convenience, to be abandoned when we learn more of the true nature of the agent.

Chemistry gives us, by analysis and synthesis, the percentage composition of a body—that is, the elements entering in it, and the proportions in which they are combined; more than this it cannot do. Knowing the percentage composition of a body, or its *empirical* formula, we conjecture as to the arrangement of the constituents and make what may be called the *rational* formula. It does not alter the nature or properties of sulphuric acid that we write its formula $HO\ SO_3$, or $H\ SO_4$, or $HO_2\ SO_2$, or $HO_3\ SO$, or $O_4\ HS$, &c.; nor do we know, nor shall we ever know, the true arrangement of the elements in other than the simplest binary compounds. Hence, we have a right to take any view which will most easily classify our facts.

Let us consider a single example: Potassium and Oxygen unite to form a compound which, when combined with the elements of water, has been called caustic potassa. Sulphur and oxygen unite to form, among other compounds, sulphuric acid, which when combined with the elements of water, forms the well-known oil of vitriol. These are plain facts, the result of experiment. If we mix these bodies in proper proportion, a compound is formed, the sulphate of potassa or "potassic sulphate." The "old" theory simply supposes that the acid united with the base, the water of each being eliminated. This may be true, or it may not, but no one can tell. It is a simple view, and has the advantage of being easily comprehended, and of aiding the memory.

If we take the formula for alum, we shall see still more clearly the advantage of the old system in aiding the memory. We suppose that the sulphate of potassa above mentioned, KO, SO_3 unites with another sulphate, say of alumina, $Al_2 O_3, 3 SO_3$, and that the two combine, and, in crystallizing, take up 24 equivalents of water. The student readily comprehends this, and can easily remember the method of manufacture and the constitution of the compound. Its apparently long formula, $KO, SO_3 + Al_2 O_3, 3 SO_3 + 24 HO$, thus becomes easy. He can then be shown how it is possible to replace the potassa with soda, ammonia, &c., and the alumina by other sesquioxides, still retaining the type and crystalline form of the original.

Thus:	$KO, SO_3 +$	$Al_2 O_3, 3 SO_3 + 24 HO.$
	NaO	Mn_2O_3
	NH_4O	Cr_2O_3
	CsO	Fe_2O_3
	RbO	
	TlO	
	AgO	

If we take the unitary formula, these advantages are, in great part, lost. Thus, in Fowne's Chemistry, the formula for alum is given as $(SO_4)_2 Al''' K. 12 OH_2$, while that of the "aluminium sulphate" or sulphate of alumina, which is absolutely put into the salt in its manufacture is $(SO_4)_3 Al'''_2 18 OH_2$. How is the student to remember such formulæ, and how is he to account for the change which "aluminium sulphate" undergoes when simply crystallized in company with "potassic sulphate?" Certainly the older formulæ are quite as reasonable as these.

Since the time of Lavoisier the balance has been the test of chemical truth. By its aid the equivalents of the elements have been determined, and for years the simple and natural method of taking the combining weights of bodies for comparison was followed. Since the introduction of "molecular" weights, as might be supposed, there has been "a most admir'd disorder." Each chemist may assume molecules according to his own theory, and the whole notation and nomenclature of chemistry is thus shifting constantly. The July number of the *Journal* contains some analyses of minerals, by Prof. Leeds. His formulæ for the silica, alumina, &c., are as follows:—SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, H_2O, evidently unitary formulæ, as shown by the Na_2O, K_2O H_2O. In the *Verhandlungen des naturhistorisch-medizinischen Veriens zu Heidel-*

berg, is given an analysis, by Prof. C. W. C. Fuchs, of a clay, the paper having been read 4th March, 1870. His formulæ are SiO_2, AlO_3, FeO_3, H_2O CaO, MgO, K_2O Na_2O. Which of the discordant formulæ is *the* unitary one? It would be easy to multiply instances from the books and papers in which the so-called molecular formulæ are found. It would seem that these theorists are like Burke's "architects of ruin" attempting to pull down and destroy, but effecting nothing solid in return.

Still more unfortunate is the disregard of facts by the enthusiastic unitarians. When the facts do not agree with the theory, "so much the worse for the facts." Without attempting to go over the ground of equivalent volumes which is full of instances, I merely take their theory of the formation of salts.

The "ancient" dogma was that "a salt is formed by the union of an acid with a base or of a halogen body with a metal." This is simple fact, whether the acid and base remain as such in the compound is not known, nor is it material. It is convenient to suppose that they do. The unitary theorists *assume*,—First, That an *acid* is a compound containing hydrogen, the whole or part of which is displaceable by a metal. Second, That a *salt* is a compound derived from an acid by the displacement of the hydrogen by a metal. This includes the simple theory of Davy, that the hydrated acids should be looked upon as compounds of hydrogen with an unknown electropositive body formed by adding the oxygen of the base to the dry acid, and the more complex water type theory of salts. Neither is in accordance with known facts. We can reasonably enough write $H\ SO_4$, $K\ SO_4$, &c., although SO_4 is unknown, because it is not new to assume the existence of a non-isolable body; for instance, that of ferrocyanogen. There are, however, facts which cannot be ignored, and there are considerations which render this view quite untenable. Thus:—

1. Certain acids, as CO_2, AsO_3, CrO_3, SO_2 (at common temperatures,) do not combine with water, hence they cannot truly be written HCO_3, $H\ AsO_4$, &c.; yet they are so written in unitary works.

2. We have well marked sulphur acids, which certainly do not contain replaceable hydrogen.

3. This view compels us to suppose in the bi-chromates, bi-carbonates, &c., distinct and wholly different acids from those in the monosalts, which experiment does not show to be true. Thus $Na\ CO_3$ $Na\ H\ C_2O_6$; $K\ CrO_4$ $K\ Cr_2\ O_7$ and even $K\ Cr_3\ O_{10}$. We are also compel-

led to admit that the phosphoric acid in the meta, pyro and ortho-phosphoric acid is not the same, but that there are in these bodies substances as distinct as are sulphurous and sulphuric acid. Thus $H\,PO_6$, $H_2\,PO_7$, $H_3\,PO_8$. This is altogether contradicted by the properties of the acid, the characters of its salts, and the facility with which they assume and part with the elements of water, being thereby transformed, the one into the other. The many other objections in point of fact and reason, need not be stated. The type theory, so well suited to the study of the complex and therefore elastic substitution compounds of organic chemistry, is illy adapted to the simpler and less flexible bodies, generally included under the head of inorganic chemistry. Thus, to represent the pyro-phosphates, we must assume four molecules of water as the type, thus (using molecular symbols) $\frac{H_4}{H_4}\Theta_4$. Then "pyro-phosphate of sodium" would be $\frac{Na_4}{(P_2O_3)''''}\Theta_4$ and "acid phosphate of sodium" $\left.\begin{matrix} Na_2\,H_2 \\ (P_2O_3)'''' \end{matrix}\right\}\Theta_4$. (*Bloxam's Chemistry*, p. 256). What a contrast to the simplicity of the "ancient" formula $2\,NaO,\,PO_5$; $NaO,\,H\,O,\,PO_5$. What is gained by the change?

It is not necessary to add more, I only wish to show that there are reasonable grounds for holding certain theoretical views which are by some believed to be accordant with facts, and certainly much more simple than those by which it is sought to replace them.

B. HOWARD RAND, M. D.

Editors of the Journal of the Franklin Institute.

IN my paper entitled "Experiment on the Evaporation of a Corliss Boiler," in your number for June last, I quoted erroneously from table II. in the *Description of Richard's Improved Steam Engine Indicator*, by taking the temperature of saturated steam, corresponding to the pressure *above* the atmosphere, as if it was the *total* pressure. The temperature corresponding to the pressure of 66·46 pounds above the atmosphere should read, 312·91°. The mean observed temperature of the steam being 311·80°. It appears that the steam was not superheated, and of course the small additions to the observed evaporation, made in the paper, on account of superheating, should be omitted. JAMES B. FRANCIS.

Lowell, Mass., June 30, 1870.

Civil and Mechanical Engineering.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. BY J. RICHARDS, M. E.

(Continued from page 21.)

THE circular saw for cross-cutting or "*butting*," represented in the last number, has, in common with all saws of its kind, the fault of cutting only at limited depths, and while it affords a ready and rapid means of cross-cutting small timber, such a machine would be of no avail in our American lumber mills, where logs of 40 to 48 inches diameter are not unfrequently met with, and the general range of timber would require saws of from 6 to 7 feet diameter.

The consumption of power, too, measured not with reference to the amount of cutting done, but by the time in which it is performed, is very great.

To pass a circular saw through a 30-inch stick in from ten to fifteen seconds, which its speed requires, would for the time absorb the power of a mill with a 20 horse-power engine, and of course derange other machinery. For these reasons, among others, we find the drag or reciprocating saw in general use for cross-cutting throughout the United States and Canada, as well as in most mills abroad.

The one in common use in the States is of the most simple con-construction, sometimes consisting simply of a crank wheel and pulley, with a rigid connection to which the saw-blade is fastened with bolts or rivets, but generally with a pendulum joint and a compound or jointed connection between the crank and saw-blade. The saw resting with the weight of one end of the connection on the log. When not in use, it can be raised out of the way and suspended overhead until again wanted, leaving the "log way" clear.

A saw of this kind making 75 strokes per minute will cut through a log of from 2 to 3 feet diameter in 3 to 5 minutes, consuming but little power, without any skilled attention.

In England the reciprocating cross-cutting machine is sometimes constructed in a more elaborate and expensive form, with metal

framing and guides at each end of the blade, the guides being mounted on saddles that move up and down upon cast iron pedestals, the main peculiarity of the machines being that the saw with its guides and straining devices can be lowered beneath the mill floor when not in use. The straggling character of these machines of every modification makes it impossible to furnish intelligible engravings within the limits of the *Journal.* Aside from the endless modification in the form of teeth for cross-cutting saws, there is perhaps but little of interest that can be said of them, except in contrasting the performance of reciprocating with circular or band saws.

The stroke of the saw, or rather the relation of the stroke to the depth of the timber, is a point about which there is much difference of opinion, even among practical sawyers; but this subject will be considered in connection with scroll-sawing machines in a future article.

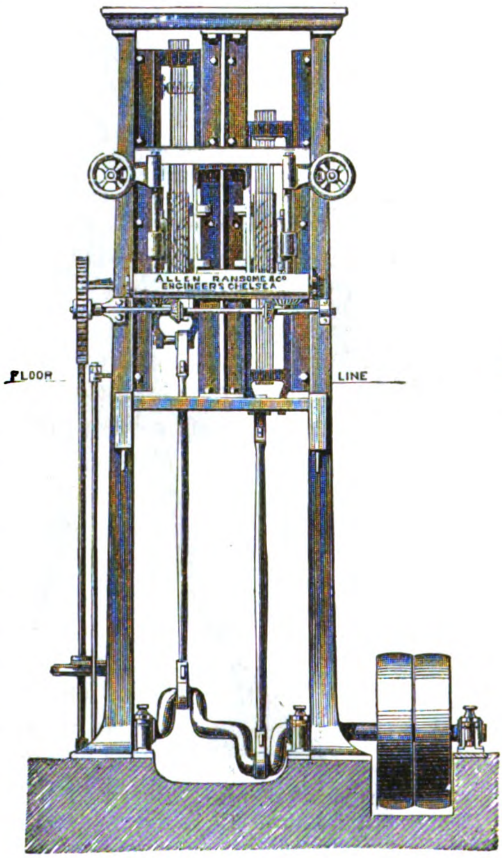
Having considered modern log reciprocating sawing machinery for what may be termed "forest" sawing, we now come to machines for "re-sawing," as it is termed in this country, or "deal sawing," as it is called in England; and in order to judge of the adaptation and merits of the machines, which will be illustrated and described, it will be necessary to revert briefly to the "lumber system" of the two countries a point that has mainly determined the character of the sawing machinery employed. In contrasting the two systems, where they differ, it would certainly be greatly to our disadvantage should we fail to consider the bounteous provision of nature through which we have enough timber both to use and to waste. The reckless manner in which we cut our lumber both as to the waste of the kerf and the irregularity of dimensions has much to do with its price, which has become a subject of serious consideration, mainly in the Atlantic cities, where its cost is already enhanced by transportation from the Middle States.

Our lumber is nearly all forest cut, that is, reduced from the log to its lowest dimensions, while green, allowance being made in the thickness for seasoning, warping and the irregularity of sawing.

In sawing a "squared stock" into 1-inch boards, with a circular or Muley mill, about one-fourth is converted into saw-dust, at least one-eighth must be allowed for shrinkage, another eighth will be required to dress it down to the dimensions of the thinnest boards, and remove the dirt and grit collected in transportation, so that when it reaches the final consumer it rarely represents more than *one-half*

of the stock from which it is cut, or about two-fifths of log before sawing. In our more expensive kinds of lumber, such as walnut, cherry and ash, this waste is becoming a serious question, and has recently become the subject of much consideration among our lumber manufacturers and dealers. It is safe to presume that as the price increases and timber becomes scarce, we will do more deal sawing, making not only a great saving in the material but enabling lumber dealers to cut their bills to special order from deals or squared stocks, without covering a large lot of valuable ground with numberless piles of stuff from which to "assort sizes."

Fig. 1.—Front.

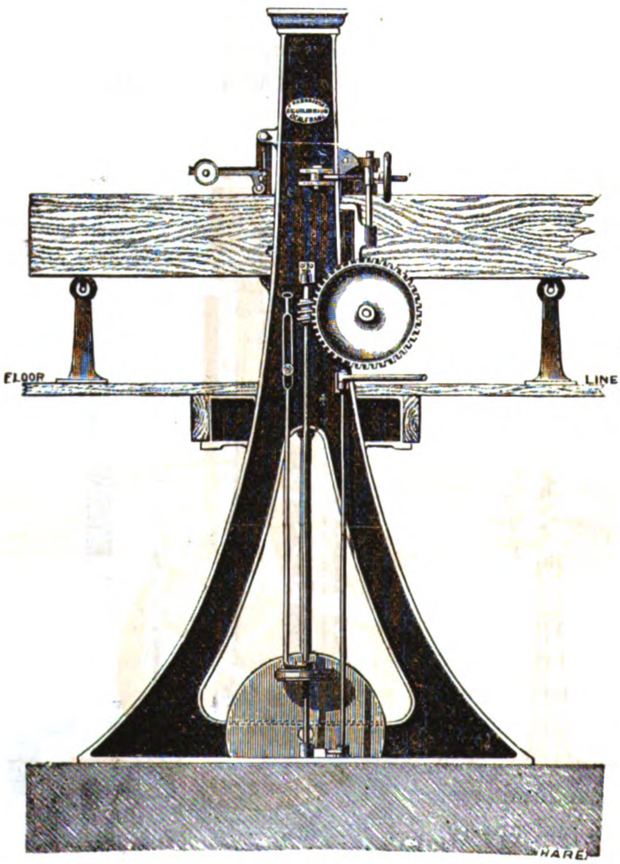


In England nearly every wood-working establishment has for its most important machines, the saws for recutting, or cutting out stuff, in fact 'saw-mill' is a common name for wood-working establishments. The timber comes from the Baltic or other parts of northern Europe and from Canada in the form of deals or heavy planks. When the log is not too large to be handled in transporting it is simply "squared," these deals are the lumber of commerce, and are resawed as needed into boards of various thicknesses on deal frames, or, as we would term them in this country, "gang resaw mills."

The saws used are of a thin gauge sufficient in number to reduce the whole deal at once passing through.

In Fig. 1 we give a front and side elevation of Fraser's patent equilibrium deal sawing machine, as improved and manufactured by Messrs. Allen Ransome & Co., which may be considered as a fair type of the most improved machines of modern times. The term equilibrium as applied to this machine relates to the compound saw frames moving in different directions at the same time by means of cranks placed at right angles with each other as shown in the engraving on page 91.

Fig. 1.—Side.



The plane of their movement is of course not the same, and although not quite amounting to a perfect counterbalance is an important improvement on the old machines with a single sash that could not be balanced in any degree to insure steadiness in the frame. This question of counterbalancing reciprocating saws will be considered

farther on, when the arrangement of this machine in this respect will be farther and more fully reverted to.

The weight of these machines varies from 2½ to 5 tons, carrying from 10 to 20 saws, and making from 140 to 230 revolutions per minute. The feed is continuous and variable at pleasure by means of the frictional disk seen in the side elevation. The writer has seen these machines making 250 revolutions per minute, with a feed of from 30 to 40 inches per minute, carrying 5 working saws on each side, in 12-inch deals, without any jar or vibration that would affect the machine, which performance, so far as any data in his possession could determine, was cheaper than any sawing we do in this country even in green timber, especially when we consider that the saws were of 14 gauge steel with but little set.

Fig. 2.—Side.

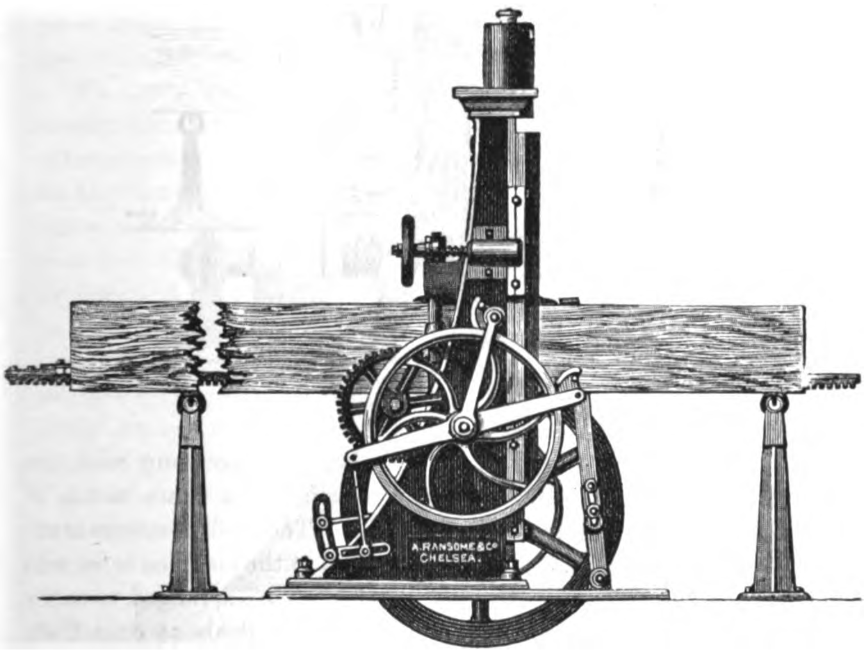
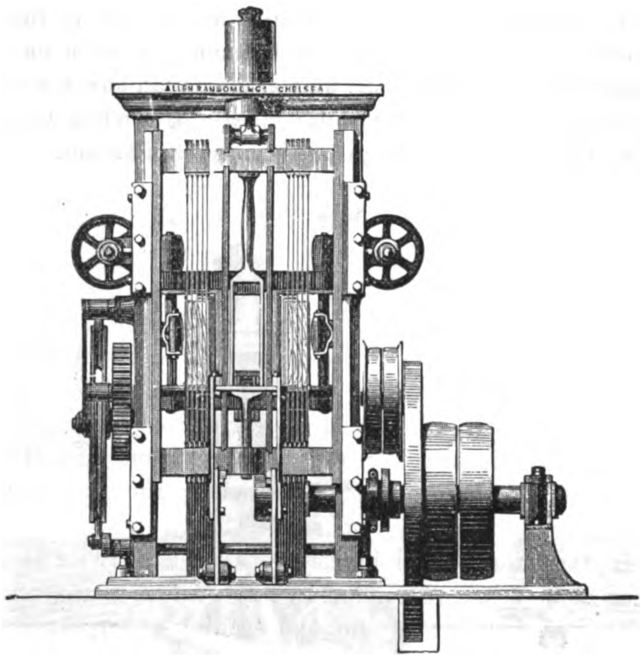


Fig. 2 is a true elevation showing two views of another modification of the deal sawing mill from the same manufacturers. It is what might within certain limits be termed a portable mill, having all of its parts above the floor-line. The connection is "forked" around the rack that feeds the timber, and attached to the top of the

saw frame; this gives it sufficient length, allowing the crank shaft to be placed above the floor as seen in the engraving. On the top of the frame will be seen a vacuum cylinder, which is fitted with an air-tight piston connected with the saw-frame.

The area of this cylinder is so proportioned as to balance the weight of the reciprocating parts of the machine making an elastic

Fig. 2.—Front.



cushion as it were on the down stroke, and dispensing with the counterbalance on the crank wheel, which is the main cause of horizontal vibration in such machines. The feed is intermittent by means of the silent clutch. The weight of the machine is for two sizes, 2 and 2½ tons, respectively. The frames are arranged to carry from fourteen to sixteen saws, and to cut two deals at once from 11 to 14 inches deep. The average speed is 200 revolutions per minute. There are not in common use in the United States any machines that correspond to these. The limited amount of re-sawing that is now done has not justified manufacturers in attempting to introduce them; in fact unless our lumber system is changed there is but little for them to do. Our re-sawing machines as now

built with their ponderous framing and single blade, are incapable of cutting lumber at a cost that can be afforded, and are only operated where they are a necessity. A discrimination in price in favor of 1-inch boards as against thinner lumber is all that enables them to be run with profit.

It is fair to presume that if we resawed our lumber to the extent that it is done abroad there would be many valuable improvements introduced to cheapen and simplify construction.

The native ingenuity of our lumber manufacturers in devising machinery of simple and cheap construction is recognized and conceded by all who have investigated the subject thoroughly. In fact, the wants of our country are so entirely different from those of any other, that it is not only difficult but impossible for any one to comprehend them unless by a very careful investigation of all the local conditions that affect them, but, as before said, when so investigated and considered by people from abroad, their adaptation has generally been recognized.

We have here, for instance, a continuous and rapid change of construction; a continual chain of improvements, following each other in such rapid succession, that the purchaser of a machine has no assurance that it will not in a year or two, be supplanted by a new modification, which, through competition, he will be compelled to adopt; hence he feels like limiting the amount of the investment to the lowest possible sum.

Again, the value of the investment is at least twice as much as in older countries. When money invested in manufacturing is worth ten per cent. per annum, and seeking other investments, it is not strange that we find in our saw-mills a rigid economy in the matter of first cost.

Another condition to be considered, and a very important one too, in connection with lumber-cutting machines, is the very general knowledge that exists of its care and operation in the United States. In our thickly populated districts (if we have any that can be so called), we are hardly ever out of the sight of the steam from saw mills. It is common for our largest farmers to use their portable engines for cutting their own lumber for building, fencing, &c., and it would be surprising to know how many of our people are acquainted with saws and saw-mill operations. This enables the use of machinery of simple construction, and small cost, which is

too often construed as exhibiting our inability to design and build that which is more durable and better.

A friend of the writer, traveling in Switzerland in 1867, investigated a saw-mill which he found there for cutting fir timber, which he describes as follows:—The water was spouted with wooden troughs to an overshot wheel of about 12 feet diameter. In the axis of this wheel there were inserted wooden lifters similar to those used for operating "Cornish stamps." The saw with its frame or attachments was lifted up by these lifters, and then "*fell down*" by its gravity in making the cut. To arrest the downward stroke and to determine the range of movement a strong beam extended down from the saw-frame, and came down at each stroke upon a bed of saw-dust and ships at the bottom. It is to be regretted that there was no sketch of this piece of engineering taken at the time, but from the description it is safe to assume that no such thing was ever seen in North America, nor any parallel for it. This is mentioned as contrasting with the general knowledge of saw mills existing here.

(To be continued.)

DISTILLING APPARATUS FOR STEAMSHIPS.

Editors Journal Franklin Institute:

THE importance of a distilling apparatus, from which may be obtained an ample supply of palatable, wholesome water, is so great on board all merchant steamers making long voyages, as well as on our naval vessels, that I am confident that the following report upon the only apparatus of this kind which has yet fully met this great want, will be read with interest by all who have been or who expect to be called upon to make an ocean voyage, as well as by engineers generally. R. H. T.

Naval Academy, June 8, 1870.

"*Mare Island Navy Yard, March* 11, 1870.

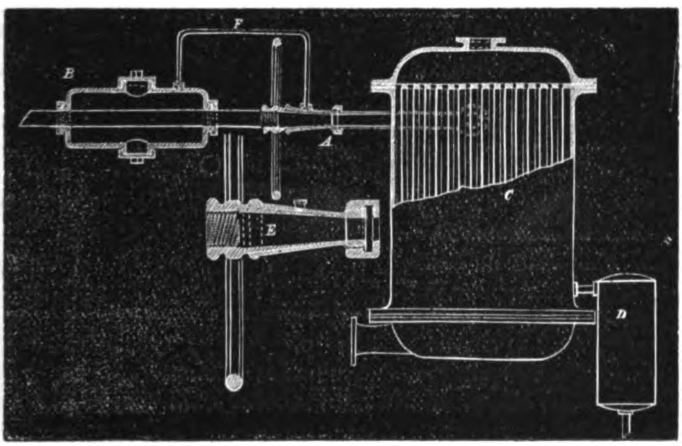
"SIR; * * * * * The water obtained on shipboard by the condensation of steam from the boiler, being the result of pure distillation, is wholly unmixed with air, is quite warm as it comes from the condenser, and is unfit for use until after several days exposure in tanks. These tanks are situated in the hold of the vessel, and the air imbibed by the water is saturated

with the bilge-water gases which accumulate in that unventilated apartment.

"The purpose of the invention of 2d Assistant Engineer George W. Baird, is to saturate the water of distillation with pure atmospheric air at the moment of condensation, thereby furnishing it thoroughly aerated, cool, and potable as it flows from the condenser.

"To effect this, an air injector, A, of very simple construction, is attached to the steam pipe, which is of no greater cost and bulk than an ordinary cock, and surrounds the pipe so that the current of steam induces an entering air current, and delivers it into the condenser against considerable pressure.

"The steam to be condensed, together with the quantity of air required for its proper aeration, thus enter the condenser thoroughly mixed, and, being in contact with each other, molecule to molecule, the water of condensation encloses as much air as it can hold, and flows from the condenser in so super-aerated a state that air bubbles from it adhere to the sides of any vessel into which it may be drawn.



"As thus delivered, the water has nearly the atmospheric temperature and is immediately potable; being already saturated with pure air, it cannot be afterward impregnated with the foul air of the hold.

"To still further oxygenize the air in the water, the steam pipe is passed through a vessel, B, containing a mixture of peroxide of manganese and chlorate of potash; the oxygen, being slowly evolved by the heat of the steam, is conveyed by a small pipe, F, to the

condenser, where it is absorbed by the water in such proportion that it acquires the taste of good drinking water.

"Incidentally, Mr. Baird's process adds materially to the cooling power of the condenser by the amount of cold air drawn in with the steam.

"The parts added to the ordinary condenser, by Mr. Baird, are the air injector, and the vessel containing the mixture of black oxide of manganese and chlorate of potash; they add but slightly to the cost and weight of the apparatus, while they add materially to its effect.

"A filter, D, of animal charcoal was used to remove any organic substances that might be brought over from the boiler, the water of which, in our experiment, was drawn from the bay, quite muddy and salt, and containing much vegetable and animal matter.

"In the experiment which we witnessed, the atmospheric temperature was 70° Fahr., and that of the aerated water was 72½° F. We are of the opinion that Mr. Baird's system of aeration may be beneficially used in all vessels of the navy."

The above report was made by a board of naval officers, Captain Reed Worden, chairman. Three chief engineers of the navy and two surgeons were among the members.

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

BY COL. O. W. CHILDS, C. E.

(Continued from page 39.)

Brito Harbor.

A harbor connecting the canal with the Pacific at Brito is to be formed by the construction of a jettie or breakwater, by excavations to extend from within the moles of the jettie at 17 feet depth of water at low tide, to the foot of the lower lock, and by the construction of a wharf along its northwesterly side, surrounded by a wall of stone masonry.

From the lower lock, the base of the hill bounding the valley on the westerly and northerly sides, lies nearly parallel with and from 4 to 600 feet from the cut below described for the artificial harbor. The hill has an elevation of from 2 to 300 feet, and extends, in a westerly direction, 50 chains, to the water-line of the coast at high tide. From this point, with the coast extending off upon a line nearly at right angles to the left, the hill continues with a slight curve, also, to the left, and with nearly a vertical face

over 200 feet high, 24 chains, to a short spur projecting from its base, and terminating in 30 feet depth of water.

$1\frac{45}{100}$ miles southerly from this point is the rocky termination in the sea of a spur from the hill, which bounds the opposite side of the valley. The indented coast fronting the valley between these two spurs is a sand beach, upon which, at a point 4 chains southerly from the south side of the projected artificial harbor, the jettie is to commence and be extended at right angles with the line of the beach 450 feet to the coast line of low-tide; thence in a more northerly direction 600 feet to its termination, in 17 feet depth of water at the entrance of the harbor. The opposite wing of the jettie is to commence at the rock base of the hill, at a point within the spur before mentioned, and be extended southerly 217 feet, and terminate in 17 feet depth of water at low tide, leaving an entrance to the harbor between the termination of the jetties 400 feet in width. The area of the sea surface enclosed by the jetties at low-tide is $9\frac{60}{100}$ acres, at high tide $20\frac{80}{100}$ acres, of which, owing to the slight inclination of the bottom, only a small portion has the depth at low tide required for the harbor. From the water-line of the coast at high tide to the location of the outer portion of the jettie, a distance of 1,000 feet, the bottom descends 26 feet: at a further distance of about 400 feet the water has a depth of about 90 feet.

From the foot of the lock the artificial harbor, as projected, is to continue in a southerly direction $2\frac{3}{4}$ chains, with a bottom width of 200 feet: it is to extend thence in a westerly direction 17.00 chains, with a width of bottom of 440 feet, thence $13\frac{60}{100}$ chains, it is 320 feet in width: from this point to its termination at the entrance of the breakwater, its average width is 450 feet; thus giving an aggregate area within the moles of $35\frac{80}{100}$ acres, with 17 feet depth of water at low-tide. The excavations embrace within their limits a portion of the present channel of the creek, which has an average width of about 150 feet. [See map page 41.]

An area of from 200 to 300 acres, with some portions of its surface below, and others from one to two feet above high tide, lies immediately adjoining the southerly side of a portion of the above line of contemplated harbor, from which, with an average excavation of 27 feet in depth, any additional harbor room may be formed that may at any subsequent period prove to be necessary. Efforts to sink shafts to the depth required for the harbor, were made at several points that were supposed would furnish a fair indication of the material of which the whole flat is composed, but owing to the influx of sand, and in the absence of the means of tubing, these perforations could only be extended to depths ranging from 18 to 24 feet from the surface, except in a single instance, in which, with great efforts, the auger was forced through the sand to a depth of 33 feet, or about 6 feet below the bottom as planned for the harbor. From the formation and general appear-

ance of this valley, and the indications from the borings, it is deemed reasonable to assume that the material of which the flat is composed, to a depth beyond that required for the harbor, is sand.

If, from an interruption of the navigation, or any other cause, there should be an accumulation of vessels at this point, beyond the capacity of the harbor as projected, a safe anchorage for any additional number that might require it, would be available in the harbors of Nacascola and San Juan del Sur, lying respectively about 10 and 11 miles south from Brito.

The canal being designed for navigation by vessels of so large a class, it is not supposed that very extensive harbor room at the ports of San Juan del Norte and Brito will be required.

The through business will probably be mainly done by sea-going vessels, constructed with especial reference to the navigation of the canal, and by others then in use, of the same and of less dimensions. The commerce of the State may be accommodated in the interior at various points on the canal, and upon the lake, also on the Pacific at the natural harbors of Fonseca, Realejo, &c., as well as that at other ports on the Pacific and on the Atlantic, by vessels that navigate the canal. The transhipment, therefore, of any very large amount of freight, or a very extensive commerce at either terminus of the canal, is not anticipated; should this prove otherwise, the enlargement of the harbors is regarded as practicable to any desirable extent, or that subsequent developments may show to be necessary.

Proceeding from 17 feet depth of water in the lake, opposite the River Lajas, in the direction of the outlet at Fort San Carlos, a distance of $59\frac{69}{100}$ miles to a point half a mile southerly from the Boccas Islands, the depth increases to 20 feet in the first quarter of a mile, to 60 feet opposite the south end of the Island of Ometepe, it is 39 feet opposite the north side of the Solentinane Islands, and from thence gradually diminishes to 14 feet at the termination of the above distance, $5\frac{50}{100}$ miles from the head of the river at San Carlos. The first 5 miles of this latter distance has quite a uniform depth, averaging, as indicated by soundings with the lead line, about 10½ feet; thence it increases to 19 feet in the channel opposite the River Frio, a sluggish stream coming in from the south, opposite San Carlos, having about 150 feet width and 10 feet depth, with a uniform flow during the dry season.

From the Boccas Islands to within half a mile of the outlet, the bottom of the lake is composed of fine clay: although there is very little agitation to the surface of this part of the lake, there being no effective current, this substance to a great extent is held in suspension by the water, and may be sensibly felt with a light rod at a depth of from 10 to 11 feet. A sufficient number of soundings were taken upon lines extending from the Boccas Islands to near the head of the river, and transversely, to show that a channel of no greater average depth than 9 feet exists in this part

of the lake, during its lowest stages; maintaining the lake at its ordinary high-water level, would increase it to 14 feet, leaving 3 feet to be added to the depth of the channel by under-water excavation or otherwise.

The channel is to be protected by a row of piles driven on each side along its whole extent, and being connected with the shores of the river would, by concentrating the flow, at least create a sufficient current to prevent subsequent deposits of earth, and probably, by its action on the bottom, would increase the depth, and perhaps to the extent required for canal: the expense, however, of excavating a channel 150 feet wide, and to the depth required between the rows of piles is included in the estimate.

A line of level was commenced at the surface of Low Lake, at San Carlos, and carried down the river on the northerly side to the harbor of San Juan. The distances and bearings of the line, as run, were accurately taken, and the depths of the river were ascertained by soundings taken at chain distances in all cases where excavations in the bed of the stream was found to be necessary, and the location of the channel, and length and position of the cuts through the bars, were determined with care by sounding and by instrumental observations from the shore. The general direction of the river is easterly: its least width is 300, and its average about 600 feet.

The whole distance from the outlet of the lake, at San Carlos, to 17 feet depth of water in the harbor of San Juan, is $119\frac{31}{100}$ miles, and the whole fall from the surface of high lake, or the elevation at which it is to be permanently maintained, to the surface of the highest tide observed in the harbor, is $107\frac{41}{100}$ feet, and to the lowest tide observed $108\frac{73}{100}$ feet.

Of the above distance, the first $90\frac{80}{100}$ miles, or from San Carlos to $\frac{55}{100}$ miles below the Serapequi River, the San Juan is to be made navigable by excavations in its bed, and by the construction of dams, to be passed by means of locks and short canals; the remaining $28\frac{51}{100}$ miles of the canal is to be constructed inland or independent of the river. Of the whole fall $62\frac{50}{100}$ feet occurs on that portion to be improved by dams, on which there is located 8 locks, the remaining $46\frac{23}{100}$ feet occurs on the inland portion of the canal, on which there is located 6 locks.

From the lake to the head of the Rapids del Toro, a distance of $27\frac{23}{100}$ miles, the surface of the river during its minimum flow has a descent of $2\frac{24}{100}$ feet. The difference between its elevation at the time it was surveyed, and that during ordinary high water, as ascertained from well defined marks repeatedly observed on the trunks of trees standing at the margin of the stream, is $5\frac{20}{100}$ feet. The slight descent in the river, and the near proximity of these marks to the lake, also renders them an unerring indication of the ordinary elevation of the surface of the lake during a large portion of the wet season.

The most extensive cut required on this distance is through the bar first occurring below the lake. The channel, with a depth of 19 feet opposite San Carlos, passes from a little south of the centre of the river obliquely to the north shore, with a depth gradually diminishing to 12 feet in a distance of $1\frac{6}{100}$ miles, and to 6 feet on the north side of an island $1\frac{50}{100}$ miles from the lake. The bar extends from the head of the island along up the stream, occupying the central portion of the river, which here has more than the usual width, and proceeding up, gradually increases from 3 to 8 feet depth of water, which continues obliquely up the river to the south shore. The water, in passing over this bar from the north, accumulates with a slightly increased velocity on the south side, thus forming a channel extending from above the lower termination of that on the north side, far down the river. In this, as in all similar cases of two channels having sufficient depth and lapping each other, the cut, designed to form a navigable connection between them, is planned upon a line nearly in the direction of the current; although this considerably increases its length beyond what would otherwise be required, it improves the direction and is deemed necessary to avoid obstruction to the navigation by subsequent deposits.

In many instances of a change of channel to opposite sides, the depths throughout are found quite sufficient, while in other cases of straight, though of broad river, the depths are insufficient, and under-water excavation will be necessary. The estimate provides for a bottom width of 150 feet at all of the cuts through bars in the river.

The following statement shows the number and lengths of the bars, between the lake and the foot of the Rapids del Toro, the extreme depth of the cut through each, and their distances severally from the lake.

No. of Bar.	Length of each Bar in miles.	Extreme depth of cutting in feet.	Distance from Lake in miles to upper end of Bar.	
1	$0\cdot\frac{650}{1000}$	4·00	$1\cdot\frac{048}{1000}$	
2	$0\cdot\frac{187}{1000}$	2·50	$2\cdot\frac{207}{1000}$	
3	$0\cdot\frac{175}{1000}$	1·00	$5\cdot\frac{781}{1000}$	
4	$0\cdot\frac{287}{1000}$	3·20	$6\cdot\frac{517}{1000}$	
5	$0\cdot\frac{325}{1000}$	4·60	$8\cdot\frac{313}{1000}$	
6	$0\cdot\frac{337}{1000}$	4·00	$9\cdot\frac{647}{1000}$	
7	$1\cdot\frac{112}{1000}$	3·50	$13\cdot\frac{233}{1000}$	
8	$0\cdot\frac{762}{1000}$	2·50	$14\cdot\frac{830}{1000}$	
9	$0\cdot\frac{762}{1000}$	2·60	$17\cdot\frac{325}{1000}$	
10	$0\cdot\frac{662}{1000}$	2·20	$20\cdot\frac{431}{1000}$	
11	$0\cdot\frac{525}{1000}$	2·50	$25\cdot\frac{309}{1000}$	Through Toro
12	$1\cdot\frac{887}{1000}$	4·50	$26\cdot\frac{76}{100}$	Rapids.

The depths in the channel between the bars range from 12 to 30 feet.

The Rapids del Toro occupy a broad section of the river, extending easterly upon nearly a direct line 1 $\frac{82}{100}$ miles. Its surface has a fall in this distance of 6 $\frac{67}{100}$ feet. The channel passes from 9 feet depth of water on the north side, immediately above the head of the rapids, along near the north shore, maintaining a depth varying from 6 to 10 feet, a distance of 60 chains; it here changes to the southerly side of the river, which descends more rapidly with a depth not exceeding 2½ to 3 feet; it then passes in the direction of the centre of the river, with a depth increasing to 8 feet at the foot of the rapids; the line as located for the cut, which will be mostly in rock, lies intermediate the centre and north shore, and nearly parallel with the latter.

At the foot of the rapids, the stream is divided by an island, the larger portion passing in a southerly direction down the deeper channel on the west side; the bed of this branch rises from 8 feet depth at the foot of the rapids to 6½ feet in three chains, and continues from 6½ to 7½ feet in depth nearly to the foot of the island, a distance of 27 chains; from this point to the head of Castillo rapids a distance of 7 $\frac{40}{100}$ miles, the river has a uniform width, and a depth varying from 12 to 25 feet approaching nearer the latter, the largest proportion of the distance; the descent on the surface of the river between these rapids in time of low water is 2 $\frac{36}{100}$ feet.

The river at the head of Castillo Rapids is 750 feet in width; it has an easterly direction 12½ chains, with a descent of 4 $\frac{24}{100}$ feet to the foot of the principal fall, where it abruptly bends to the south; it continues this southerly direction 16 chains, with a further fall of 1 $\frac{66}{100}$ feet to the foot of the rapids, where it has a width of 825 feet, and is 22 $\frac{7}{100}$ feet below the surface of high lake. It here curves to the east, and with a small branch passing on the northwesterly side of an island, a projecting point of table land is formed in the bend of the river on the north side.

The line as located occupies the channel 6 feet in depth on the north side of a small island, at the head of the rapids, and continues along near the north shore 24 chains, in 3 feet depth of water, to near the lower end of the principal fall, where it leaves the river, and is carried across the point 17 $\frac{72}{100}$ chains over a surface of favorable elevation, and by 2 locks of 8 feet lift each, it again enters the river opposite the lower end of the small island before mentioned, 0 $\frac{52}{100}$ miles from the head of the rapids. The surface of the river, at the point of entrance, is 22 $\frac{30}{100}$ feet below the high lake.

Eight chains above the lower end of the rapids, a dam designed to elevate the water 21 $\frac{66}{100}$ feet, is located on rock across the river, in an average of 3 $\frac{81}{100}$ feet depth of water, and an extreme depth, one chain in width, of 12 feet; the dam is to have a length of 1 $\frac{5}{100}$ feet of which 700 feet will occupy the present channel of the river, and 350 feet is to be extended in a trench cut down to the rock,

inland, on the southerly side to the base of the hill. A guard embankment will be necessary to extend from the north abutment of the dam $4\frac{50}{100}$ chains to the upper lock, and from the north side of said lock $5\frac{50}{100}$ chains to the hill. The dam is designed to elevate the surface of the river, at the head of Castello Rapids, $16\frac{21}{100}$ feet, at the foot of the Rapids del Toro, $13\frac{91}{100}$ feet, at the head of the latter rapids, $7\frac{24}{100}$ feet at the Lake of Nicaragua, 5·00 feet above the lowest stages to which the surface at these places severally subsided at the close of the dry season of 1851.

The surface of the river at the point of entrance below the second lock being $22\frac{39}{100}$ feet below the contemplated surface in the pond of the dam, and the lockage in crossing the point of land being 16 feet, the river at the foot of the lock will require to be raised $6\frac{39}{100}$ feet by the succeeding dam No. 2. The least depth of water upon the line below the point of entering the river is 4½ feet; the greatest depth of cutting will be $6\frac{11}{100}$ feet; the cut will be extended down nearly in the direction of the centre of the river to a point 2¾ miles below, where it terminates in $8\frac{20}{100}$ feet depth of water.

From the above connection of the line with the river to the head of the Mico Rapids, a distance of $5\frac{17}{100}$ miles, the surface, by a uniform descent, falls $4\frac{32}{100}$ feet; thence in a distance of $2\frac{70}{100}$ miles to the location of the dam, at the foot of Balas Rapids, the surface descends $7\frac{3}{100}$ feet.

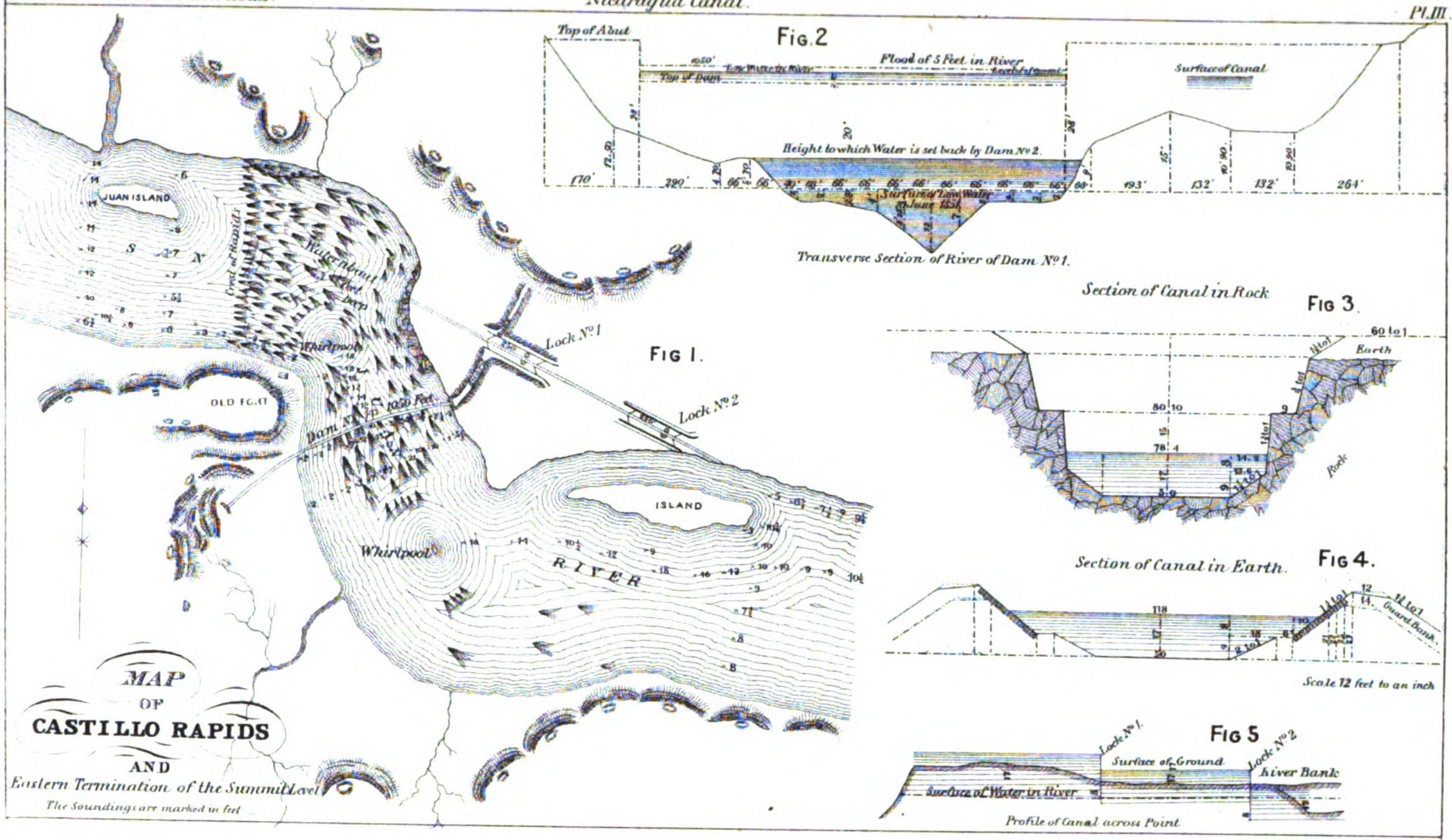
The transverse section of the stream upon the line to be occupied by the dam, has an average depth of $5\frac{96}{100}$ feet, and an extreme depth of 10 feet; the dam is located nearly at right angles with the river, on a foundation of rock, and terminates on the south side against a precipitous hill, also composed chiefly of rock. Upon the north side a flat elevated 7 feet above the water extends from the river 7 chains to the base of the hill. The dam is to have a length of 567 feet, and is to elevate the surface of the river at this point $17\frac{74}{100}$ feet, at the head of the rapids $10\frac{71}{100}$ feet, and, as before stated, $6\frac{39}{100}$ feet, at the foot of the lower or lock No. 2 at Castillo. The canal has a length of $13\frac{39}{100}$ chains, and by a cut is to be carried through the flat with an easy curve, around the north end of the dam, and by a lock of 8 feet lift, it connects with the river below. The cut in the bed of the river below this lock, has a length of $0\frac{62}{100}$ miles, and an extreme depth of 1 foot.

The river below the dam becomes broad, and pursuing an easterly direction, the water with a comparatively thin volume, passes over a rock bed with a velocity greater (except at the rapids) than is usually found in other parts of the river, and with a fall of $4\frac{94}{100}$ feet in a distance of $2\frac{48}{100}$ miles to opposite the foot of an island.

At the junction of the canal with the river, immediately below the dam, the river has a depth of 6¼ feet, and proceeding down in the channel near the north shore it increases to 8 and 10 feet, which latter depth, with little exceptions, continues to the foot of the

Nicaragua Canal.

Pl. III.



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island. The channel continues thence on the north side of the river 18 chains, where the river bends to the north, and extends in this direction with from 15 to 20 feet depth of water in a narrow channel along the left shore, and with a broad and shallow river on the right, to the head of the Machuca River, a distance from the foot of the island of $\frac{65}{100}$ miles, and with a fall of $\frac{71}{100}$ feet, or a fall of $5\frac{65}{100}$ in a distance of $3\frac{13}{100}$ miles from the foot of the lock at dam No. 2.

At the head of the rapids the river curves to the east, and in a distance of 48 chains measured on the northerly side, it has a descent of 4 feet; it continues this easterly direction 26 chains, to where it again, by a short curve, takes a northerly direction 21 chains, with a fall in this distance of $3\frac{21}{100}$ feet to the foot of the rapids, making an aggregate distance from the head to the foot of the rapids of $1\frac{19}{100}$ miles, and a fall of $7\frac{21}{100}$ feet.

Near the head of the rapids dam No. 3, $1\frac{056}{1000}$ feet in length, is located across the river in an average of $6\frac{34}{100}$ feet, and at one point in 16 feet depth of water; on the the south side it abuts against a precipitous rocky hill, and on the north it terminates in a recess to be cut into the vertical face of the bank bounding a flat elevated 8 feet above the surface of the water. By this dam it is designed to raise the water $15\frac{39}{100}$ feet at the head of the rapids, and $9\frac{74}{100}$ feet at the foot of dam No. 2; and the canal as located is to leave the river opposite the island above mentioned, or 52 chains above the dam, and be carried along the base of the hills over a generally uniform and quite level surface across the two points formed by the bends of the river, and by two locks, Nos. 4 and 5, the former of $6\frac{50}{100}$, and the latter of 8 feet lift, again enters the river at the foot of the rapids in the distance from the point of divergence opposite the island of $1\frac{68}{100}$ miles; deducting from the sum, of the fall at the dam, and the descent from the head to the foot of the rapids, together, $22\frac{60}{100}$ feet, the descent by the two locks $14\frac{50}{100}$, and it leaves $8\frac{10}{100}$ feet as the height to which the surface of the river at the foot of lock No. 5 is to be raised by a succeeding dam to be located across the river below. The depth of water in the river at the entrance of the line below lock No. 5 is $2\frac{90}{100}$ feet; a cut, therefore, of 6 feet in extreme depth in earth and rock will be required to extend upon a line forming a favorable connection with that inland down the river 25 chains to its termination in $8\frac{90}{100}$ feet depth of water.

From the foot of Machuca rapids to the confluence of the San Carlos, a distance of $16\frac{47}{100}$ miles, the surface of the river has a descent of $2\frac{8}{100}$ feet.

From the junction of the two rivers to the location of dam No. 4, a distance of $3\frac{50}{100}$ miles, the surface has a descent of $4\frac{83}{100}$ feet. The channel of this section is broad, and ranges from 9 to 14 feet

in depth. The whole distance from the foot of the Machuca rapids to dam No. 4 is $19\frac{97}{100}$, and the fall is $6\frac{91}{100}$ feet.

The dam is located nearly at right angles with the river in an average depth of $10\frac{73}{100}$ feet, and an extreme of 13 feet depth of water, on a light gravel consisting of the debris of a soft volcanic rock brought down by the San Carlos, and deposited over a large portion of the bed of the San Juan, from the junction of the two rivers to the Atlantic. The material is of a light yellowish color, and presents in appearance a striking contrast with that more weighty and dark colored, constituting the gravelly portions of the bed of the San Juan above, and with the more firm and compact material of which the earth portions of the bed of the San Juan below the junction are composed. Its general depth is not known, although variable, it is probably not deep, as boulders were discovered above its surface at various places in the bed of the stream.

The dam is to be 841 feet in length, and be placed in a trench to be excavated across the river to a depth equal to that in the channel; it is to raise the water $15\frac{1}{100}$ feet at its location, $10\frac{8}{100}$ feet at the confluence of the San Carlos, 8·10 at the foot of lock No. 5, and $10\frac{2}{3}$ inches at the foot of dam No. 3, at the head of Machuca rapids. It is to terminate at its south end at the base of a hill, and on the north side a flat, elevated 14 feet above the water intervenes between the river and a hill, affording favorable grounds on which to construct the canal 11 chains in length around the north end of the dam.

A lock of 8 feet lift is located in the cut, which reduces the surface of the canal to within $7\frac{1}{100}$ feet of the surface of the river below the dam.

The succeeding $22\frac{40}{100}$ miles are to be made navigable by three dams, Nos. 5, 6 and 7, to be constructed across the river severally at distances of $7\frac{54}{100}$, $8\frac{60}{100}$ and $6\frac{26}{100}$ miles from dam No. 4, and from each other, and by canals at Nos. 5 and 6 severally, of $11\frac{27}{100}$ and $18\frac{65}{100}$ chains in length, in each of which is to be placed a lock of 8 feet lift. The bed of the river at the site of the dams is to be lowered in the same manner as at No. 4. The present average depth of water at the sites is severally $9\frac{50}{100}$, $15\frac{84}{100}$ and $16\frac{25}{100}$ feet; the extreme depth is $13\frac{1}{4}$, 28 and 22 feet. The water is to be elevated $14\frac{46}{100}$, $15\frac{75}{100}$ and $13\frac{59}{100}$ feet, severally, at the sites of Nos. 5, 6 and 7, and below Nos. 4, 5 and 6, $7\frac{1}{100}$, $6\frac{45}{100}$ and $7\frac{75}{100}$ feet, leaving a fall at these latter dams of 8 feet each, and at No. 7 of $13\frac{59}{100}$ feet.

The lengths of dams Nos. 5, 6 and 7 are severally 726, 627 and 891 feet, and the country on either side of the river at the sites, is in all respects similar to that described at the location of No. 4, except that the hill on the south side at No. 5 is 7 chains from the river, with an intervening flat 12 feet above the water, and at No. 7 the hill is 1 chain from the river. No excavation in the bed of

Statement in Tabular Form of the Location, Distances, Elevations, &c., of Dams Nos. 1 *to* 7, *inclusive.*

No.	Location of Dams.	Distance from Dam to Dam in miles.	Dist. from Lake in miles.	Length in feet.	Elevation of water. Minimum flow in feet.			Fall at Dams in feet.	Quantity of flow in cubic feet.		Thickness of volume on Dam in feet.		Inclination in feet per mile—High Water.	Mean velocity in miles per hour—High Water.
					Above Dam.	Below Dam.	Foot of Lock.		High Water.	Low Water.	High Water.	Low Water.		
										Above	Toro Rapids.		0.121	1·10
1	Castillo.	....	37·12	1050	21·66	5·66	6·39	16·00	20,497	11,930	2·67	1·94	0 029	0·76
2	Los Balas......	7·46	44·58	561	17·74	9·74	9·74	8·00	20,497	11,930	4·13	2·95	0 079	1·07
3	Machuca.......	3·13	47·71	1056	15 39	0 89	8·10	14·50	20,497	11,930	2·78	1·97	0·042	0·76
4	....	21·00	68·91	841	15·01	7·01	7·01	8·00	27,981	15,192	4·58	2·80	0·054	0·78
5	....	7·54	76·25	726	14·45	6·45	6·45	8·00	38,088	15,192	4·94	2·92	0·150	1·45
6	....	8·60	84·85	627	15·75	7·75	7·75	8·00	41,566	16,626	5·88	3·45	0·161	1·60
7	....	6·26	91·11	891	13·59	....	....	13·59	55,530	22,212	5·67	3·28	0 085	1·22

the river between these dams will be required. These dams are large, and in construction will be difficult and expensive.

In the following statement of the elevation of the surface of the river, &c., by the dams, no allowance is made for inclination.

Twenty-four chains above dam No. 7, the canal, as above stated, is taken from the river, and with the exception of three spurs which approach the river, requiring in passing them an extreme depth of cutting severally of 38, 47½ and 42½ feet, the line occupies highly favorable grounds, having an average elevation of about 9 feet above the surface of the river a distance 7·53 miles to the divergence of the Juanillo branch of the river; here the valley of the San Juan assumes a much greater width, and the Juanillo, with a width of one chain, and a depth at ordinary high water of 5 feet, passes from the main river, and, with many meanderings, flows in a general direction northwesterly a distance of about 23 miles, where, with a width of 4 chains, and a depth of 9 feet, it again unites with the San Juan $2\frac{81}{100}$ miles above the harbor. The canal, in crossing the head of this branch, will cut off the flow from the river; the line thence passes over the generally uniform surface of the flats along the San Juan $4\frac{05}{100}$ miles, to nearly opposite the Colorado branch, where leaving the margin of the river, it is traced $0\frac{80}{100}$ miles in rear of some conical hills occupying a slight bend in the river directly opposite the Colorado, and with favorable cutting again approaches the river. From this point the line traverses a widely extended and uniform plain $13\frac{58}{100}$ miles to the point of crossing the Juanillo, 35 chains above its connection with the San Juan. The surface of this plain opposite the Colorado, is about 8 feet above the surface of the river, and by a quite uniform inclination descends to 1½ feet above the surface of the Juanillo, which has here about the same elevation as the San Juan. The canal is to cross in the channel of the Juanillo, with an average excavation of 3½ feet below its bed, and a new channel is to be cut on the upper side, and nearly parallel with the line, through which the stream is to be conducted to the harbor. From the Juanillo the line is extended in a northwesterly direction $1\frac{79}{100}$ miles, and with the exception of an intervening lagoon, requiring about 5½ feet depth of excavation ¾ of a mile, it passes over a low though generally uniform surface, varying in elevation from a few inches below to 1½ feet above the surface of the ordinary high water of the river, to the location of the lower, or lock No. 14, connecting the canal with the artificial harbor. From the junction of the Juanillo, the San Juan, with many windings, takes a northerly direction $2\frac{7}{100}$ miles to where it changes to the north, and by several channels enters the easterly end of the harbor.

The excavation at the surface of the short canals passing the dams at Castillo, Balas and Machuca, will be in earth; at the bottom the material is rock; at all of the remaining dams the material is a loamy clay with a small proportion of fine gravel.

The peculiar contour of the surface along the line from dam No. 7 to the divergence of the Juanillo is such as to require but few culverts, and no aqueducts will be necessary below the latter point; with the San Juan on one side, and the Juanillo on the other, the country may be drained from the canal in either direction to these streams, consequently these structures will not be required on this part of the line.

(To be continued.)

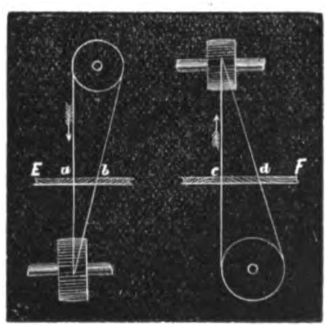
BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 38.)

Holes for Quarter-turn Belts.

Draw on a level floor with chalk line and tram, two full size views of the pulleys and position of the floor through which belts are to pass, or lay them down on paper to a convenient scale: observing that, *that fold of the belt which leaves the face of one pulley must approach the centre of the face of the other in a line at right angles to the axis of the latter.* Completing the figures as shown, the points of intersection *a b c* and *d* will indicate the places in the floor, E F where the centres of both folds of the belt will pass when drawn tightly and at rest. We copy diagram from *Sci. Amer.*

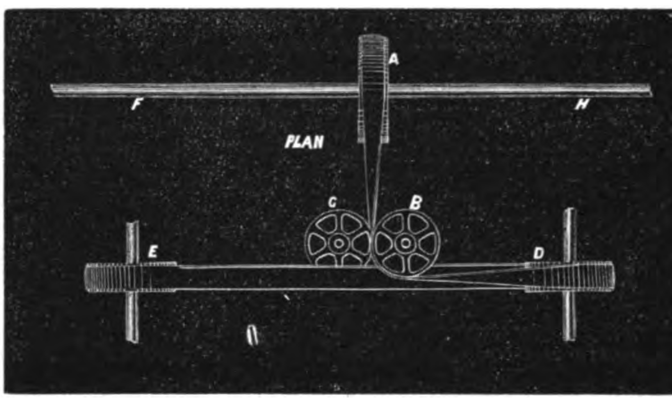


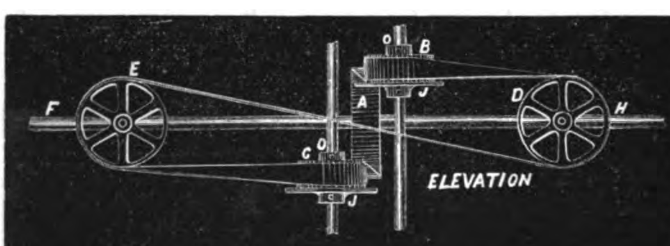
The obliquity of the opening can best be obtained by trial of tape line or narrow belt applied to the pulley faces in position, passing through small trial holes in the floor. Allowance in the hole should be made for the sag of slack fold of belt.

About 25 per cent. of belt contact is lost when the belt makes a quarter-turn, even when the pulleys are of the same size. We have noticed in the performance of a *leather* belt that the first 90° of lap on the pulley fit closely as in the ordinary straight belt arrangement; but in the second 90°, about half the width of the belt is forced from contact with the pulley by the strain in the substance of the belt, due chiefly to its imperfect elasticity and primarily to the oblique deflection of the fold which is leaving the pulley.

With a belt perfectly elastic the same amount of contact, if not more, can be obtained, as with the open belt, since the belt would adhere to the face of the pulley up to the line of departure the same in one case as in the other.

To drive two shafts at right angles to the main by one belt.—Let A be the driving pulley on the main shaft, F H; D and E the driven pulleys on the counters, at right angles to the main. Place two upright shafts, each with a loose pulley, so that its face will be opposite the middle of the face of A,—one to the right and one to the left. Over these pass a belt, as shown in the cuts. The belt will run either way.—W. H. H. W., in *Sci. Amer.*, May, '69, p. 340.





It will be observed that the driving face of the belt is changed between the two pulleys, D and E, which may be avoided by giving the belt a half twist in this part, which we think, however, would injure the belt more than by using both sides.

It is evident that if the pulley, B, is placed on the same shaft with C, and above it, opposite its present place, and the belt joined between E and B, and not carried to D, that the usual "corner-turned"

belt arrangement will be obtained, of which the plan here shown is an extension. Collars O and O are placed over the pulleys B and C, and we have added the stationary flanges J and J to the uprights under the pulleys, which Messrs. Wm. Sellers & Co., of this city, have the credit of inventing and introducing. This device, whether applied to vertical or horizontal pulleys, is in every way superior to flanges on pulleys which tend to lift the edges of the belts, and finally to roll them and turn them over. On the other hand, when the belts strike stationary flanges, they are thrown back on the pulley faces again.

Belting.

Horse power of a belt equals velocity in feet per minute, multiplied by the width,—the sum divided by 1000.

One inch single belt, moving 1000 feet per minute = one horse power.

Double belts about 700 feet per minute, per one inch width = one horse power.

For double belts of great length, over large pulleys, allow about 500 feet per minute per one inch of width per horse power.

Power should be communicated through the lower running side of a belt; the upper side to carry the slack.

Average breaking weight of a belt $\frac{3}{16}$ inch thick one inch wide; of leather 530 lbs., of 3-ply rubber 600 lbs.

The strength of a belt increases directly as its width.

The coefficient of safety for a laced belt is:—for leather $\frac{1}{16}$ of its breaking weight, for rubber $\frac{1}{8}$.—*W. G. Hamilton, Useful Informa- for Railway men.*

Example for Working Belt.

A single leather riveted belt of ordinary make connects a 60-inch to a 30-inch pulley; both of smooth turned cast iron: the centre of the latter being 8 feet horizontally distant 5 feet above that of the former. The 60-inch pulley drives and makes 80 revolutions per minute, the top fold of belt sagging 13 inches from the straight line. This belt does not slip, runs with the hair side to pulleys, has been in use more than six years, was originally 9 inches wide is now 8 inches, runs one inch crooked, and during the first two years of its existence was exposed to the weather, frequently saturated with water, but is now soft and adhesive by the application of prepared castor oil.

Horse power transmitted, 14·48 indicated, which is equivalent to 57·826 square feet of belt traveling per minute per horse power.—*F. W. Bacon, New York.*

Eel-Skin Belt Lacings.

"I would say that from them are made the most valuable strings for lacing belts in the world. One lace or string will outlast any belt, and will stand wear and hard usage where hooks or any other fastening fails. The skins are dried and then slit lengthwise, and can be ready for use in three hours time from the catching of the eels."—*J. W. B., in Sci. Amer., June* 4, '70, *p.* 364.

To take Oil out of Leather.

Mr. A. D. Fisk, of Newark, N. J., says:—"In the factory where I am employed we use 4 F *aqua ammonia*, which will take oil out without injury to the leather.

"It must be use two or three times in order to get it all out. First use it and let the leather stand until more comes out, and apply again. This is the only thing that will take it out and not hurt the leather."—*Sci. Amer., July*, 1869, *p.* 19.

Belt for Cooling Shaft Journals.

A very ingenious as well as simple method of cooling a journal, consists in placing an endless belt of loose water-absorbing texture on the shaft, as near the heated part as may be, and allowing the lower bight to run in cold water, which may be held in a vessel at a convenient distance below the shaft.

Continuous contact of the liquid band carries away the heat of friction as it is produced, without spilling or splattering of water on and about the machinery, and without contact of the lubricant in the journal boxes.

We have seen this method successfully applied to the shafts of the rolls of calico printing presses.

Covering for Pulleys.

Pulleys may be well covered in the following manner:—take a piece of belt leather of uniform thickness the width of pulley face, and of a length equal to circumference of pulley, plus the lap, but less $\frac{3}{8}$ inch for every foot of diameter of the pulley, then scarf and unite the lap so as not to increase the thickness when cemented to-

gether. When ready for use draw the covering on by means of iron hooks, observing to put hair side out and so that outer end of lap will not be raised when covering slips under the belt. Secure to the pulley rim by copper rivets, sinking heads beneath the driving surface.

The laps of all belts should be disposed in a similar way.

(To be continued.)

ALLEN'S ENGINE.

From W. S. Auchincloss' Report, Paris Exposition, 1867.

"THE engine invented by Mr. J. F. Allen, of New York, has been greatly modified in the hands of Mr. Charles T. Porter, of the same city, and made a special branch of manufacture by the Whitworth Company, Manchester, England.

"The latter have placed three representative engines on exhibition in the British department,—one for driving a portion of the line shafting in the main building, and two of smaller proportions arranged with excellent forethought for illustrating the principle and detail of the parts. The former has a cylinder 12 inches diameter and 24 inches stroke of piston: 200 revolutions per minute is the average velocity, giving, consequently, a piston speed of 800 feet per minute. While one of the latter has certain sections removed, revealing thereby the valves, steam passages, piston, &c. A slow speed, imparted through a belt to the fly-wheel, clearly demonstrates the manner in which the governor and valves perform their respective functions. Its consort is operated by steam, and astonishes engineers who have been accustomed to speeds varying between 200 or 300 feet per minute, by its wonderful rapidity. The maximum number of revolutions attained has been as high as 700, corresponding to a piston speed of 2800 feet per minute, and yet this remarkable feat was accomplished without jar or noise, so perfectly are the parts fitted and balanced. The large engine is furnished with a jet condenser, which is simply a modification of the approved form used in marine engines. It is placed on a separate foundation, immediately back of the steam cylinder, and has for a displacement piece a single-acting cast iron plunger, operated by the prolonged piston-rod.

"To adapt this to the requirements of the high speed incident to

its connection, the point of the plunger is turned with the same radius of curvature that Mr. Whitworth has found most efficient on his celebrated projectiles; also, its weight exactly equals that of the amount of water displaced.

"Besides these precautions, small diaphragm plates are attached inside of the condenser, to prevent the generation of waves, which would result from the sudden impact of the plunger against the water. The rubber disc-valves have but a short motion, and are self closing, by means of spiral springs.

"The main bed plate of the engine extends from the cylinder head, to which it is bolted, to a point sufficiently beyond the crank shaft for receiving the large pillow block of the same. This bearing is unusually long, and this insures absolute rigidity of the shaft. The connecting rod, formed of steel, has a length equal to thrice the stroke.

"Since Mr. Allen's engine is based on the principle that work should be performed by the development of high velocity in a small mass, the fly-wheel is consequently of much less magnitude than used on engines of equal indicated power.

"The cylinder is duplex; that carrying the piston forms a sleeve-like casting, which is bored and turned, then forced into the outer cylinder, where, being supported only by fitting strips at the extremities, it is effectually guarded by a complete envelope of steam from irregular expansion.

"With reference to the proper piston for a high speed engine, Mr. Porter has found the most satisfactory results to accompany the use of one without packing, but with a wide face, carefully turned to the same diameter as the bore of the cylinder, and having the same channeled by small V-grooves. These lodge the water condensed from the first steam that enters the cylinder, and thus create a packing of sufficient resistance for the steam.

"There are two valve-chests on the side of the cylinder,—one for the valves regulating the steam, the other for those controlling the exhaust. The former valves are rectangular, and work between scraped surfaces; they are balanced by the pressure of the steam on their opposite sides, while the latter are of the same construction as the ordinary flat side valves. These valves being placed near the extremities of the cylinder, the cubic contents of their passages is reduced to a minimum, a condition of economy too often overlooked in high speed engines, especially locomotives. All the val-

ves are actuated by one stationary link. Motion is transmitted to those regulating the exhaust through a "rocker," having opposite arms; the connecting stem being pinned rigidly to the top of the link, imparts an invariable action to the valves. The steam valves have their stems attached to other rockers, and these in turn have connecting stems pinned to the sliding block of the link.

"To this block the "Porter patent governor" is connected, which, acting under an increased or diminished velocity, causes the block to traverse the link, and effects an earlier or later cut off of the steam. The combination is very sensitive, and when running with a light load cuts off almost simultaneously with the commencement of the stroke.

"An invariable "lead" results from the stationary link, which latter is a curious modification of the ordinary form; for, instead of receiving its motion from two eccentrics, having each a connecting rod, the link-block is cast *on* the strap of the eccentric. Its position is maintained by the ordinary mode of suspension, and the distance from its centre to that of the main shaft is made thrice that of the eccentric's throw; the latter is placed in the radial plane of the crank-pin axis, and on the same side of the main shaft as the pin.

"As already intimated, the Allen engine, by using velocity instead of mass for the development of "work," has been brought to an exceedingly compact compass. It is perfectly under the control of its steady, yet keenly sensitive, governor, while the rapid expansion of high pressure steam in its jacketed cylinder is accomplished free of condensation, and attended with well known results. It has worked with remarkable smoothness and regularity during the exposition, and daily furnished indicator cards, clearly illustrating the perfection of its parts. Fig. 1 is copied from "Bourne's Hand Book of the Steam Engine," p. 518. Cylinder 8 inches diameter, 24 inches stroke; 150 revolutions per minute; steam 49 lbs. per square inch in

Fig. 1.

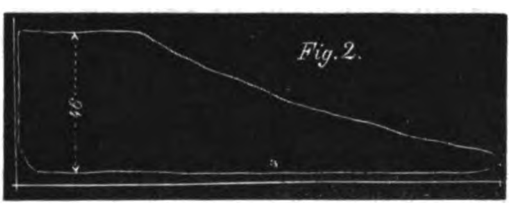


Fig. 2.

boiler. Fig. 2 is a copy of card taken from an Allen Engine built by Messrs. Cresson & Smith, of this city. Cylinder 10 inches diamer, 24 inch stroke; 144 revolutions per minute.

Average of 3 cards, crank end	27·13	lbs.
Back pressure	3·33	"
Average of 3 cards back, end	23·13	"
Back pressure	3·87	"
Average pressure	25·13	"
" back pressure	3·60	"
Effective horse power	33·8	"
Steam pressure in boiler, per square inch	65·	"

Exhaust forced through building for heating purposes. J. H. C.

Transparency of Galena.—L. Henry.—In the *Ber. d. Deutsch. Chem. Ges.*, we meet with a communication of some interest upon the above-mentioned subject. The author first gives a general review of the state of our knowledge concerning the transparency of various metals in thin laminæ, and then mentions the discovery, by him, of the same property in thin layers of Galena. The light transmitted is, according to him, of a brownish-yellow color. Several other minerals of similar chemical composition, the sulphides of Arsenic and of Mercury (auripigment and cinnabar) had been known to possess this property, but neither of the minerals named possess metallic lustre, so that to the eye there is nothing to betray their metallic character. With Galena, however, the case is different, its lustre is characteristically metallic, and is one of its distinguishing properties. The commonly accepted association in the mind of the mineralogist, of the two properties of opacity and metallic lustre in descriptive determinations, may, as appearances seem to indicate, have to suffer some restriction in the light of future investigations in this direction.

Gain in Weight by Combustion.—D. H. Briggs.—Having seen a notice of a mode of illustrating the gain in weight by combustion mentioned in the May number of this *Journal*, the author gives a simpler method of his own. He takes some iron by hydrogen in a thin iron disk, balances it accurately in the scale-pan, and ignites with a match. As the combustion proceeds the pan containing the burning material gradually sinks until its fall is checked by the table.

Mechanics, Physics, and Chemistry.

ON A SIMPLIFICATION IN THE CONSTRUCTION AND USE OF THE HOLTZ MACHINE.

BY J. C. POGGENDORFF.

(Translated from the Ann. d' Phys. und Chem., pp. 139—158.)

BY PROF. LEEDS.

(Concluded from page 61.)

AS ALREADY mentioned, the machine can be put in action by the fixed disk also, if previously it be oppositely electrified in its two halves. If the movable disk be rotated for some time, then brought to rest and all the electricity conducted away by touch from the strips and electrodes, and finally, the rotation be renewed, the machine comes again into full activity. This is the operation of the fixed disk. The same is evident from the fact that if this disk, during the period of rest, be turned through 180°, the direction of the current is reversed.

Moreover, if the (previously polarised) fixed disk during the time of rest be altered in its position 90°, the machine comes again into activity when the rotation is renewed. And this case is especially interesting, because the toothed strips, if only two be attached to the disk and they do not exceed the usual size,* are put out of action.

The current is purely the effect of two electrophori arising out of the polar condition of the fixed disk,—one positive, the other negative,—before which the movable disk rotates. Therefore it is obtained of the same intensity and direction, whatever may be the direction of rotation of this disk. But the brushes of light on the

* If, on the contrary, these strips (as Mr. Holtz has done of late, in order to increase the effectiveness of the oblique conductor,) be lengthened by a bow-shaped strip of paper to a quadrant, so that their ends in the given position of the fixed disk reach to the horizontal brass combs, then the phenomena are quite the same as if the fixed disk had not been turned 90°. The current, however, is inconstant and feeble, and the assistant conductor, whatever may be its position, destroys it utterly.

With such quadrant-shaped strips, and the given position of the fixed disk, the current is excited in the usual way, if this disk be electrically indifferent, only it is much weaker than in case the combs stand nearer the teeth; moreover, the assistant conductor cannot be employed.

disk turn themselves about on a change of direction. They are always opposite to it.

The direction of this electrophorus current depends entirely upon the phase in which the fixed disk is placed, since the brass combs always send out the opposite electricity to that which the halves of this disk, that stand over against them, possess.

The intensity of this current is considerable. I have obtained sparks of five inches in length by means of it, and when the brass combs are connected by a metallic, liquid or gaseous conductor, it has also a perceptible duration.

Nevertheless it cannot take the place of the proper current of the Holtz machine, nor as Bertsch believes, that which he has called forth by a caoutchouc electrophorus. It lacks the principle of the constant renewal of electricity, by which the Holtz machine, so long as it is kept in rotation, and the electrodes afford a sufficient connection of the brass combs, becomes an inexhaustible fountain of electricity.

The electrophorus current gradually diminishes, not only because the electrophori little by little lose their power, but also because they experience a reaction from the side of the rotating disk and the brass combs, in consequence of which they slowly become electrified in another phase. As an indication of this is the fact, that when the fixed disk is restored to its original position, there is either no current, or it is in the opposite direction to the primitive.

Even though, according to all which precedes, no practical value can be attributed to the electrophorus current, yet it has nevertheless sufficient theroretical interest, to make it appear desirable to give to the machine an arrangement adapted to the observation of this current.

To this end a fixed disk with two strips could be added; but I believe that this would not be necessary. It would suffice to make two of the teeth removable from the disk with four strips.

Finally, another interesting combination should be mentioned here, by which, along with the proper current of the machine, which I shall term the primary, still another current is obtained, that is to be regarded as secondary.

For this object the fixed disk must be provided with two toothed strips of the usual size, and must be so placed, that one of these strips stands vertically beneath the other. If, now, the movable assistant-conductor be also brought into a vertical position, the ma-

chine can be excited in the usual way,* and the secondary stream can be called forth in the electrodes of the horizontal combs—those to which no toothed strips stand opposite.

The last current proceeds of course from the rotating disk. If, for example, positive electricity be conveyed to the upper strips, by touching it with the plate of an electrophorus, the opposite comb of the vertical conductor sends out a stream of negative electricity upon the disk. This negative electricity is conveyed by the rotation to the horizontal comb, lying to the right, which accordingly sends out positive electricity. In like manner, the lower comb of the vertical conductor sends out positive electricity, which is conveyed by the rotating disk before the horizontal comb lying to the left, and causes this to send forth negative electricity.

Reckoned from negative to positive, the current in the vertical conductor goes from above downwards, and in the horizontal electrodes from left to right. If the last current proceeded from the fixed disk, since this disk by means of the strips is oppositely electrified to the rotating, it must necessarily have a contrary direction through the vertical conductor. Experiment confirms this: for, even if the vertical conductor be taken away, a secondary current is obtained. It is, however, weaker, and in the contrary direction.

The current, which is observed in the absence of the vertical conductor, is only the differenue between two secondary currents, and this adequately explains why this complex current is comparatively so small in quantity. The sparks which are obtained by the introduction of jars, follow each other but slowly. They have, however, a considerable striking distance. When I make the negative electrode end in a ball two inches in size, I obtain sparks of more than six inches in length.

Moreover, it is a peculiarity of this combination, that the long sparks are more easily obtained than the short. The longer the sparks are in the secondary current, the better does the primary current develop itself. The latter, in this case, takes the place of the rubber in the ordinary electrical machine, in that it supplies the rotating disk with electricity.

If the sparks of the secondary current be liberated for a long time, it is observed that they succeed each other more and more slowly,

* In order to excite the primary current, it is nevertheless necessary to separate the electrodes of the secondary; otherwise it occurs with extreme difficulty and perhaps not all.

and finally cease altogether. This is plainly the effect of the contrary secondary current in the hinder fixed disk, which becomes the more electrified the longer the machine remains in operation.

To escape this evil, I provide the fixed disk with large windows in front of the combs of the horizontal electrodes, so that the rotating disk can affect these combs only. No change is made in the toothed slips before the vertical conductor.

The consequence of this alteration corresponded to my expectation.

The hinder secondary current was gotten rid of, and the sparks now appeared in equal times, however long the machine continued in operation.

The slow and equable development of electricity in this current, along with the good property, which it has in common with the current previously termed the electrophorus current, make it especially suited to charge jars and batteries up to certain degrees.

Translator's Remarks.

Perhaps the most important observation in the above memoir is that which relates to the polar condition of the teeth of the paper strips. It is a matter of peculiar difficulty to determine the electrical signs of the various parts of the Holtz machine, on account of the highly electrified condition of the surrounding air, when the machine is in operation. But if we accept the statement of Poggendorf, as one founded on experiment, it requires us to interpret the phenomena of the Holtz machine in a manner different from that followed hitherto.

With regard to the substitution of a conductor like tin foil, it will be well to state what was done previously in this country. It was found that many pieces of glass, when used as sectors, and covered with strips and teeth of paper only, operated very imperfectly, and sometimes not at all. This difficulty has been overcome by pasting a thin strip of tin foil beneath the paper along the edge of the glass sector, and continuing it through the middle of the tooth. The tooth, in this case, is formed of two strips of paper pasted upon the tin foil. The tin foil facilitates the discharge of electricity scattered over the surface of a poor conductor like paper.

With regard to varnishing the paper, two things are to be noticed: 1st. That paper is hygroscopic, and the varnish applied

to its surface, like the varnish applied to the other parts of the machine, lessens the deposition of moisture. In a recent number of the *Rep. fur Exper. Physik* (Bd. V., No. 6), Dr. Carl gives a long series of observations upon the variability in the performance of the Holtz machine. They confirm a previously accepted view, that the nearer the humidity of the air at any temperature is to the point of saturation, the greater is the amount of moisture which is condensed upon the surface of hygroscopic bodies, and the greater the electric conductibility of the air. 2d. It is stated by Professor Morton (*Jour. Frank. Inst.*, LII., p. 420), in the case of a Holtz machine made by Ruhmkorff, "that it was found to operate in a very satisfactory manner for some days, but suddenly, without any evident cause, failed entirely (though the weather was very dry and cold,) to yield anything more than the most insignificant and feeble sparks. This failure led to a long series of experiments, the result of which has been to show that, for efficient working, the strips of paper attached to the fixed disk should be very slightly insulated on their surfaces, but as thoroughly as possible upon their edges. * * * This may be best done by shellac varnish, applied in a narrow line, on the edge. * * *" Now, if we grant that the teeth and strips are in a polar condition, the former operating by discharge, the latter by induction, it will follow from the same course of reasoning which led to the adoption of a strip of tin foil to facilitate the discharge of electricity from the one, that we should add an insulating material to prevent the escape of electricity from the other. Since the edge of the strip acts by induction upon the brass comb opposite, the electricity should be concentrated at this pole in a line with the comb, and should not be allowed, as the tension mounts higher and higher, to spread out upon the surface of the sector.

Whatever might be the operation of two small holes filled in with disks of cork, it certainly would not be a very elegant construction. As yet, the European makers of this machine do not appear to have availed themselves of the improvement, which was first suggested in an article by Prof. Morton (*Jour Frank. Inst.*, LIII., page 119), the division of the fixed disk into separate sections. This construction was followed by Mr. C. T. Chester (*id.* LIII., p. 253), and also by Mr. E. S. Ritchie (*id.* LIII., p. 344). Mr. Ritchie has greatly simplified the machine, and rendered it less liable to get out of repair, by introducing a central plate of thick glass, which

supports not only the axle of the rotating disk, but also the sectors and combs.

Mr. Poggendorf states, that "if the fixed disk be turned around so that the strips lie inward and the teeth outward, the machine does not perform." It is probable that this statement was founded on observations of the working of the machine, at a time when its operation was impeded by external and deceptive influences. This supposition is in accordance with the experiments of Prof. Morton *Jour. Frank. Inst.*, LIII., p. 119): "The expedient of turning the plate around, so as to have the papers on the outside, and thus secure the brass plate itself as a means of insulation was tried, but not found satisfactory, owing, as is now believed, to accidental causes, such as dampness, hasty adjustment, &c. * * * On another occasion, when the air was very dry and the adjustment good, the machine was run for a long time, and with great satisfaction, in this way. We can, therefore, recommend this plan for adoption whenever a machine loses effect by leakage. If the fixed plate is reversed and adjusted as close as possible to the other, all the quantity effects can be obtained as before, the length of spark only being shortened somewhat."

The use of the quadrant-shaped strip of thin paper, alluded to in the translation, is explained by another article in *Pogg. Ann.* (1869, No. 1), which states, that in order to prevent the reversions of the current, Mr. Holtz provides the machine with a conductor which stands obliquely to the horizontal electrodes and connects an upper and a lower comb. The paper strips are lengthened out about 90°, so that their extremities stand opposite to the combs of this oblique conductor.

While endeavoring to present the modifications which have been proposed to the Holtz machine, we should mention the following by Mr. Kundt (*Rep. für Exp. Physik*, Bd V.). An ordinary cushion, covered with amalgam, is made to rub against one side of a rotating glass disc. On the other side of the disc, two brass combs are placed, one opposite the rubber, the other 180° distant. In explanation of the operation of this machine, it is said that, "As soon as the rotation of the disk begins, the side rubbed by the cushion (we will call it the hinder) becomes positive. When the rubbed sector is turned 180°, negative electricity issues from the brass comb, which binds the positive upon the hinder side of the disk. More negative electricity, of course, issues than is necessary to effect the

binding, because this issues from points (? Trans.). The conductor, united with this brass comb, becomes positive; the sector of the disk, in passing, becomes positive on the hinder side, in front, negative, with an excess of—E. When this sector of the disk comes back to the rubber and to the cushion, the excess of — E goes into the first brass comb. Then begins the peculiar action of the machine. Since the cushion is isolated, the — E which is excited by rubbing, collects upon it to the greatest possible extent. The cushion, consequently, influences directly and with considerable intensity the first brass comb. Out of this comb then + E streams out upon the front side of the disk, so that when the disk leaves the cushion, it is positive upon both sides. Of this + E, that upon the front side of the disk goes directly into the second comb; when it comes round to this comb, that upon the hinder side exerts the influence above mentioned. During the rotation, the disk is always positive in the upper half, (the disk rotating like the hands of a watch, and the cushion situated at the left, and in contact with the hinder side of the disk,) positive behind, negative in front, with an excess of negative electricity."

In reading the above and other explanations of the mode of operation of the Holtz machine, we are impressed with their insufficiency to account for the complicated phenomena connected with the machine. The ordinary analysis of electricity into positive and negative seems too feeble to cope with the exigencies of the present case. We would offer, merely as suggestions, the following views: When a charge of electricity is communicated to the strips, their teeth and edges may be regarded as poles, whence originate and terminate curved lines of electric force. The particles of air surrounding these poles arrange themselves in definite positions along these lines, and if they were visible, these lines of force would reveal themselves to us, in the same way as iron-filings reveal the invisible lines of magnetic force which exist at all times around the poles of a magnet. The particles of the rotating disk, in their forward movement, are constantly tearing through these lines of force, so that the force which has originated at any moment from a pole, is prevented from returning in its own normal curve. The forces thus disrupted will follow those paths which offer the least resistance, *i. e.*, the conducting wires, and the current which we see traversing the electrodes is the result of this endeavor to re-establish an equilibrium. The decompositions and re-combinations which

take place along these lines of force, and result in the formation of great quantities of ozone, are no more to be disregarded than are the chains of metathetical reactions in the fluid surrounding the plates of a galvanic battery.

ON A NEW CHROMIUM OXYCHLORIDE.

By T. E. Thorpe, Ph. D.

(From the Proceedings Lit. and Phil. Society of Manchester, Vol. IX., No. 3.)

When chromyl dichloride $CrO_2 \left\{ \begin{matrix} Cl \\ Cl \end{matrix} \right.$, prepared by heating a mixture of potassium dichromate, sodium chloride, and sulphuric acid, is maintained at a temperature of 180°—190° in a sealed tube for three or four hours, it is almost completely converted into a black solid substance, and on opening the tube when cold a conciderable quantity of free chlorine escapes. By exhausting the tubes containing the liquid chloride before subjecting them to heat, I have ascertained that chlorine is the only gaseous product of this decomposition. The black compound invariably contains more or less of the liquid chloride which has escaped decomposition: the greater part of this is easily expelled on gently heating the mass after opening the tube. In order to free it completely from the latter body, the black substance was transferred to a clean tube and heated to 120° (*i.e.* about 2° above the boiling point of chromyl dichloride) in a current of dry carbonic acid gas until its weight appeared constant. The following determination of the amount of chlorine contained in the volatile portion shows that it is simply chromyl dichloride which has remained undecomposed.

0·8741 grammes liquid chloride gave 1·6458 grammes silver chloride.

Calculated for $CrO_2 Cl_2$,	Found,
45 7 per cent.	46·5 per cent.

The solid substance dried in the manner above described appears as a black uncrystalline powder, which, when exposed to the air, rapidly deliquesces to a dark reddish brown syrupy liquid smelling of free chlorine. When thrown into water it quickly dissolves, forming a dark brown solution, which on standing also evolves chlorine. In the nitric acid solution hypochlorous acid appears to be produced. In strong hydrochloric acid the substance dissolves with a dark brown coloration; and on boiling the solution chlorine is evolved, the liquid becomes greenish yellow, and ultimately changes to the dark green color peculiar to a solution of chromium sesquioxide in hydrochloric acid. When it is thrown into dilute ammonia, chromic acid is dissolved, together with all the chlorine, and a precipitate is formed possessing the properties of the chro-

mate of chrome sesquioxide ($Cr_2O_3CrO_3$) described by Storer and Eliot. Upon this decomposition is based the method which I have employed for the estimation of the amount of chlorine contained in this body. The weighed quantity of the substance was treated with very dilute ammonia; the solution boiled for a few minutes and filtered; the precipitate well washed by hot water; an excess of nitric acid added to the filtrate; and the chlorine precipitated by the addition of silver nitrate. Two determinations of chlorine carried out in this manner on preparations made at different times gave the following results:—

Preparation I.

0·5900 gram substance gave 0·4870 gram silver chloride, and
0·0069 gram metallic silver.

Preparation II.

0·493 gram substance gave 0·4250 gram silver chloride.

Preparation I	20·80	per cent. Cl.
Preparation II	21·32	"
Mean	21·06	

In order to determine the amount of chromium it contains, a weighed portion of the substance was repeatedly heated with strong hydrochloric acid on a water-bath until the evolution of chlorine entirely ceased: the solution was then diluted with water, heated to boiling, ammonia added in slight excess, and the solution again boiled until the supernatant liquid appeared perfectly colorless. The precipitated chrome sesquioxide was then filtered, dried and weighed.

Preparation I.

0·3442 gram substance gave 0·2470 gram chrome sesquioxide.
0·5900 " " " 0·4235 " " "

Preparation II.

0·5082 gram substance gave 0·3590 gram chrome sesquioxide.
0·5942 " " " 0·4210 " " "

Preparation I	49·30	per cent. Cr.
	49·25	"
Preparation II	48·45	"
	48·62	"
Mean	48·91	

Hence the percentage composition of the substance is as follows:

	Found.	Ratios.	Calculated.
Chlorine	21·06	2	21·86
Chromium	48·91	3	48·54
Oxygen	30·03	6	29·60
	100·00		100·00

I have attempted to control the above empirical formula ($Cr_3O_6Cl_2$) by heating a weighed portion of the substance in hydrogen. The action of hydrogen upon the new chloride when heated is extremely

energetic. At a comparatively low temperature it takes fire, combustion proceeds rapidly throughout the mass, and ultimately the substance is converted into chrome sesquioxide, hydrochloric acid and water. Care must be taken to regulate the current of hydrogen, since, if it is too rapid, particles of the finely divided sesquioxide are apt to be mechanically carried away. From an experimedt in which the gas was carefully purified from oxygen by passing it through strongly alkaline pyrogallate solution and over heated metallic copper, and then dried by transmitting it through tubes containing pumice moistened with strong sulphuric acid, the following numbers were obtained :—

0 8715 gram substance gave 0·6150 gram chrome sesquioxide.
Found 70·58 per cent $Cr_2 O_3$.
$Cr_3 O_6 Cl_2$ gives by calculation 70·72 "

I had an additional object in thus studying the action of hydrogen upon the new chloride. I considered that this action might possibly throw some light on the constitution of this compound. The new oxychloride may, in conformity with the analytical results, be regarded as a compound of chromous chloride with two equivalents of chromium trioxide. Now, chromous chloride, according to Moberg, may be heated in hydrogen to the softening point of glass without suffering decomposition; and if it were found that water was the only volatile product of the reaction, we should possess a certain amount of evidence for supposing that the formula $CrCl_2 . 2CrO_3$ represents the constitution of this substance. Experiment showed, however, that the chlorine was not so firmly united in this compound as in the chromous chloride; on gently heating the substance in hydrogen, hydrochloric acid was immediately evolved.

Péligot has described a series of salts to which are assigned the general formula $M\,Cl . CrO_3$ and $M''Cl_2 . 2CrO_3$, where M represents a univalent metal and M'' a bivalent metal. The following are the names and formulæ of the salts prepared by Péligot :—

$K\,Cl . CrO_3$	Potassium chlorochromate.
$Na\,Cl . CrO_3$	Sodium chlorochromate.
$NH_4\,Cl . CrO_3$	Ammonium chlorochromate.
$Mg\,Cl_2 . 2CrO_3$	Magnesinm chlorochromate.
$Ca\,Cl_2 . 2CrO_3$	Calcium chlorochromate.

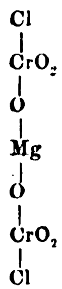
Now the new oxychloride stands in a very evident relation to these compounds. Supposing for a moment that the formulæ given to these substances correctly represent their constitution, then the new oxychloride may be regarded as the chromium term of the series—bivalent chromium replacing magnesium or calcium.

$$Cr''Cl_2 . 2CrO_3,$$

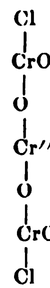
a formula identical with that of which I have just attempted to show the impropriety. But there is still another reason for sup-

posing that a compound thus constituted could not exist. Chromous chloride is one of the most energetic deoxidizing agents known, and we can hardly conceive it to be united in a stable compound with a substance which so readily parts with its oxygen as chromium tri-oxide. Hence I am disposed to regard the constitution of the salts of Péligot as very different from that implied by the above method of representation: indeed, to the best of my knowledge, the general formula assigned to these salts expresses not a single experimental fact, unless it be the mode of their decomposition by water, probably it had reference to the views of Rose and Berzelius respecting the constitution of the so-called chlorochromic acid. The following structural formulæ better represent in my opinion the constitution of these compounds and their relation to chromyl dichloride.

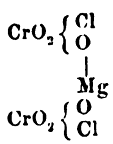
Magnesium Chlorochromate.

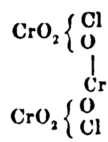


Chromium Chlorochromate.



These substances may also be thus represented:—





The relation of the new oxychloride to chromyl dichloride is thus very apparent. Three molecules of chromyl dichloride when heated are resolved into one molecule of chromium chlorochromate and four atoms of chlorine.

ON NONTRONITE.

By T. E. Thorpe, Ph.D.

(From the Proceedings Lit. and Phil. Society of Manchester, Vol. IX., No. 1.)

There exists some doubt among mineralogists as to whether Nontronite is to be regarded as a distinct mineral species. Owing to the difficulty of obtaining it in a fit state for investigation, the few analyses hitherto published by Berthier, Dufrénoy, Jacquelin

and others have taught us but little concerning its true nature. The following analysis made on a comparatively pure specimen may throw additional light on the constitution of this compound. The sample analyzed was discovered unclassified in the mineralogical cabinet at Heidelberg, and was stated by Professor Blum, who was disposed to regard it as Pinguite, to have been found in the neighborhood of Heppenheim in the Bergstrasse.

1·4155 grm. of the substance was heated with fuming hydrochloric acid until the mineral appeared to be completely decomposed; the solution was evaporated to complete dryness, and the separation of the silica effected in the usual manner.

Silica obtained, 0·5680 grm.

The weighed silica was then dissolved in caustic potash and proved to be entirely free from sand or quartz.

To the filtrate from the silica were added a few drops of nitric acid, the solution was boiled and the iron precipitated by ammonia.

Ferric oxide, 0·5757 grm.

The weighed precipitate was next dissolved in strong hydrochloric acid, water added, and the solution filtered from a minute quantity of silica which had escaped separation by the previous evaporation.

Silica (not completely separated), 0·0030 grm.

Caustic soda was then added in slight excess to the filtrate, and the ferric oxide again precipitated, washed, ignited and weighed. The re-precipitated ferric oxide weighed 0·5740 grm. Hence the substance was free from any appreciable quantity of alumina.

To the ammoniacal filtrate a few drops of ammonium oxalate were added, and the precipitate was ignited and determined as caustic lime.

Lime, 0·0380 grm.

On adding sodium phosphate to the filtrate a mere trace of magnesia, appearing only after the lapse of some hours was found.

The remaining constituent, namely, water, was determined by igniting the mineral in a stream of dry carbonic acid carefully freed from air, until the loss of weight appeared constant.

1·1205 grm. substance lost 0·2311 grm. water.

Calculated from the foregoing analysis, the composition of the mineral is as follows:—

Lime	2·68
Magnesia	Traces.
Ferric oxide	36·44
Silica	40·30
Water	20·98
	100·40

On subtracting the lime, which evidently may be regarded as an unessential constituent, the percentage composition agrees very well with that required by the formula—

$$Fe_2O_33SiO_2 + 5H_2O.$$

	Found.	Calculated.
Ferric oxide	37·24	37·20
Silica	41·29	41·86
Water	21·47	20·94
	100·00	100·00

Nontronite is evidently a product of the decomposition by weathering of some siliceous mineral rich in iron. It possesses a light green color, which, on the expulsion of water, changes to a dark chestnut brown. It is perfectly opaque, and shows no evidence of crystallization. Its fracture is uneven, and the lustre of its streak resinous. It is unctuous to the touch, yields easily to the nail, and is somewhat harder than talc.

The following analysis by Biewend, made upon a specimen found at Andreasberg, agrees remarkably well with the foregoing determinations:

Ferric oxide	37·30
Silica	41·10
Water	21·56
	99·96

ON THE NEW CHEMICAL NOMENCLATURE.

By Dr. Adolph Ott.

(Continued from page 53.)

Advanced chemists have foreseen the difficulties to be encountered in applying old and familiar names to the new notation, and several authors of recent works have given the terminals *ous* and *ic* to names of metals to indicate their combinations with electronegative elements. Yet, this system of names does not give any idea of the actual composition of the body so named. The London *Chemical News* of November 26, 1869, in a favorable review of Dr. Odling's "Outlines of Chemistry," says: "As a consequence of this method it happens that bodies differently constituted have similarly constructed names; thus $Cu\,O$, $Fe_2\,O_3$ and $Sn\,O_2$ are cupric, ferric and stannic oxides, respectively." And we may here add to this frank confession that similar names applied to combinations of metals with the monatomic halogens produce still greater confusion. These difficulties are entirely obviated in the new

nomenclature, and in making this apparent, it will be essential to show some complete series of compounds, in which will be found more than ten atoms of the same element, it therefore becomes necessary here to explain the author's system of counting more fully. The dipthongs are used to denote the even numerals between ten and twenty, in which the vowels still have their original value, either as short or long, thus *oi* is $12 = 9 + 3$; *ou* is $14 = 9 + 5$; *au* is $16 = 6 + 10$; *oo* is $18 = 9 + 9$. To designate 11 *aa* (having the sound of *ah*) is sometimes used; *y* is 10, and is used only before the short and long vowels for expressing numerals from 10 to and including 20; *w* is used for 20 in connection with the vowels for denoting numbers to 30. The well-known sign for 10, *x*, is also used and when *preceded* in regular order by a short or long vowel it will express a progression by tens to 100, *ax* being 10 and *eux* 100. In like manner the vowels before *qu* express a progression by hundreds; for example, *equ* is 200, and *euquix* is 1030. The cases of higher combinations than 100 of the same elemental atom are exceedingly rare, but it is satisfactocy to know that provision has been made for high members by a system which any one can master upon a second or third reading. We shall presently see, as we enter the domain of Organic Chemistry, how important this numerical system becomes in designating homologous bodies. Promising this much, we are prepared to comprehend more perfectly the following list of compounds, each containing the same metal, iron, in which the terms, according to the old system with its latest improvements, are placed side by side with the new names. As the word "iron" is commonly applied to the commercial article, which is a mixture of iron and carbon, our author prefers to designate an atom of pure iron by *ferram*, two atoms being *ferrem*, &c.

OLD NAMES.	NEW NAMES.
Ferrous fluoride, formerly protofluoride of iron,	*Ferramef.*
Ferric fluoride, formerly sesquifluoride of iron,	*Ferramif.*
Ferrous chloride, formerly protochloride of iron,	*Ferramed.*
Ferric chloride, formerly sesquichloride of iron,	*Ferramid.*
Ferrous bromide or dibromide of iron,	*Ferram·b.*
Ferric bromide or tribromide of iron,	*Ferramib.*
Ferrous iodide or diiodide of iron,	*Ferramev.*
Ferric iodide or triiodide of iron,	*Ferramiv.*
Protocyanide of iron	*Ferramarn.*

Phosphides of iron to which the *ous* and *ic* terminals cannot be intelligibly applied.

Fe P, *Ferramap;* Fe_3 P_4, *Ferrimop;* Fe_2 P, *Ferremap;* Fe_3 P, *Ferrimap.*

Protoxide of iron or ferrous oxide,	*Ferramat.*
Black or magnetic oxide or ferroso-ferric oxide,	*Ferrimot.*
Sesqui or peroxide of iron, or ferric oxide,	*Ferremit.*
A nameless oxide (Berthier and Glassoe) Fe_6 O_7	*Ferreameet.*
Scale oxide of iron (inner layer) Fe_8 O_9,	*Ferreimeot.*
Octoferric sulphide	*Ferreimas.*
Hemisulphide of iron	*Ferremas.*
Protosulphide of iron or ferrous sulphide,	*Ferramas.*
Sesquisulphide of iron or ferric sulphide,	*Ferremis.*
Ferroso-ferric sulphide, or magnetic sulphide,	*Ferrimos.*
Disulphide of iron (iron pyrites),	*Ferrames.*
Ferrous selenide	*Ferramaz.*
Ferric selenide,	*Ferremiz.*

In the name of salts containing two elements with one atom of a metal the name is abbreviated by omitting the vowel before *m;* and it will be here seen that Dr. Tillman is the first to denote the exact number of atoms of water in crystallized salts.

Sulphite of iron, ferrous sulphite,	*Ferrmasit.*
The same with 3 aqua,	*illt-Ferrmasit.*
Sulphite of sesquioxide of iron,	*Ferremasut.*
The same with 6 aqua,	*eallt-Ferremasut.*
Sulphate of protoxide of iron,	*Ferrmasot.*
The same with 1 aqua,	*allt-Ferrmasot.*
The same with 2 aqua,	*ellt-Ferrmasot.*
The same with 3 aqua,	*illt-Ferrmasot.*
The same with 4 aqua,	*ollt-Ferrmasot.*
The same with 7 aqua, (Green vitriol or copperas),	*eellt-Ferrmasot.*
Sesquisulphate of protoxide of iron and 7 aqua,	*eellt-Ferremisaat*
Sulphate of sesquioxide of iron,	*Ferremisoit.*
Sulphate of protoxide and sesquioxide of iron,	*Ferrmasot-Fer-[remisoit.*
Seleniate of protoxide of iron,	*Ferrmazot.*
Seleniate of sesquioxide of iron,	*Ferremizoit.*
Carbonate of protoxide of iron,	*Ferrmarit.*
Silicate of protoxide of iron,	*Ferrmakit.*

Silicate of sesquioxide of iron and 3 aqua,	*illt-Ferremikeot.*
Oxalate of protoxide of iron, and 2 aqua,	*ellt-Ferrmerot.*
Monophosphate of protoxide of iron,	*Ferremelepeit.*
Metaphosphate of sesquioxide of iron,	*Ferrmipot.*
Tri-Ferricyanide and bi-sesquicyanide of iron and 18 aqua (Prussian blue),	*yeillt-Ferreemyeirn.*
Ferricyanide of potassium,	*Potimirn-Ferremirn.*
Ferrocyanide of potassium,	*illt-Potemern-Ferramarn.*

It should be here frankly stated that the old system of nomenclature utterly fails to provide consistent names, or even any names, for some of the recently discovered compounds. A case in point is the list of ferric hydrate modifications given in the London *Chemical News* (XVII., 56), by Bush and Rodman. They are only recognized by the chemical symbols which we give in the following table with their appropriate names under the new system.

1.	Fe_4, 12 HO	*oillt-Ferrom,*
2.	$Fe_4\,O_1$, 10 HO	*eullt Ferromat.*
3.	$Fe_4\,O_2$, 8 HO	*eillt-Ferromet.*
4.	$Fe_4\,O_3$, 6 HO	*eallt-Ferromit.*
5.	$Fe_4\,O_4$, 4 HO	*ollt-Ferromot.*
6.	$Fe_4\,O_5$, 2 HO	*ellt-Ferromut.*
7.	$Fe_4\,O_6$,	*Ferromeat.*

The list of well-known iron compounds could be greatly prolonged, still sufficient are here presented to show the precision and perspicuity of the new plan. It seems quite obvious that other metallic salts are designated by this system with equal facility, but it yet remains to ascertain whether the author can pass the severe ordeal of Organic Chemistry, and provide a name for each of its numerous combinations. The examination of this question is reserved for future papers.

(To be continued.)

Decrease of Rain in France.—S. Meunier.—The author states that it appears more and more certain, that the annual quantity of rain is rapidly decreasing. The cause is attributed to the cutting down of forests, and to the fact that insufficient care is taken to keep the mountains well covered with vegetation.—*Chem. News.*

THE SUN.

(A course of five lectures before the Peabody Institute of Baltimore, January, 1870.)

By B. A. Gould.

I HAVE undertaken the somewhat adventurous enterprise of presenting in four lectures what might more fitly demand tenfold that number, viz: a general view of the present condition of our knowledge regarding the Sun. Many circumstances concur to render the subject a difficult one, and the questions continually suggested by even a superficial study are such as to lead us to some of the highest and most recondite problems of chemistry, of mechanics, of mathematics, and of physics. Such questions cannot, of course, be discussed in a popular lecture, they can only be alluded to; yet they are forced upon our attention, while at the same time many an inviting path of research is opened to our view, each one of which constitutes in itself a special department of science.

Any strict division of the topics involved in the study of a scientific problem is, of course, out of the question. In the varied and apparently limitless realm of nature, there are no sharp boundary lines, but the ramifications from every direction intertwine. This fact is remarkably manifest in the present case; yet some sort of classification is needful, and an endeavor to devise the simplest order of presentation for the various parts of our subject has led to the general arrangement which, with your permission, I will adopt. I propose, therefore, to consider in this first lecture the general astronomical facts which pertain to the sun as a heavenly body; in the second, those which careful inspection of the surface discloses to the observer; in the third and fourth, the results of physical investigations, and the disclosures made by total eclipses, concerning the material of which the sun consists, and in the last, the general inferences deducible from the various data at hand for our guidance and instruction. Thus in these five lectures we shall in general be regarding the sun, 1st, from a purely astronomical point of view, 2d, in its heliographic aspect, as an object of natural history, 3d, in its physical character, and 4th, in its theoretical and cosmical relations, as regards structure, character and origin, and the sources of its tremendous energy.

If there be any material symbol of majesty or glory known to man, it is surely that resplendent luminary which is for us the source of light and heat; whose splendor the unprotected eye may

not behold; the mere direction of whose meridian rays prescribes the tropic and the polar climates, and dictates the vicissitudes of summer and winter. The mighty alternations of day and night are but the tokens of his presence or absence in our firmament; while the effulgence of the full-orbed moon, the brilliant radiance of Jupiter or Venus, and the magnificence of the comet whose streaming banner floats across the sky, are but the feeble and distant reflections of his beams. No wonder that in the dawn of civilization this monarch of the day represented the impersonation of Deity, and received the homage of mankind as the type of sublimity, eternity, immortality, beneficence and power. What the Ghebers and Zends of old, in their untaught simplicity, and the disciples of Zoroaster in later days, assumed, the revelations of modern science have shown to be the truth; and it is no longer a figure of speech, but a scientific verity, that this refulgent day-star is the fountain of all terrestrial energy, upon whose quickening beams all earthly life depends, and to whose rays we owe all that distinguishes our world from a vast and desolate aggregation of inert and effete matter. Well did Theon,* the father of Hypatia, speak of it as "the all-vivifying heart of the universe."

It would be a vain task to attempt any investigation of the history of our early astronomical knowledge of the sun. Herodotus relates† that Thales of Miletus predicted the total eclipse which occurred‡ in the year 584 B. C., during the sixth day of a battle between the Medes and Lydians, and which by its awe-inspiring influence brought their five years war to a close. We know, too, that Pythagoras and his immediate pupils taught the doctrine which he not improbably learned in Egypt, where he had studied, that the sun is the centre of the universe, and that the earth revolves around him once a year. Three and a half centuries later, Archimedes§ correctly determined the sun's apparent diameter, as between 27′ and 33′. Although its distance from the earth, and its actual size have likewise been subjects of investigation for thousands of years, it is only in comparatively very recent times that any near approach

* THEONIS SMYRNÆI *Platonici Liber de Astronomia;* Edit. Martin, 1849, pp. 192, 298; *Humboldt*, Kosmos III., 407.

† HERODOTUS; Book I, § 74.

‡ AIRY, *Philos. Transactions*, 1853, p. 191; Mem. R. Astr. Soc. XXVI, 131.

§ In his Ψαμμιτης —See Delambre *Hist. de l'Astr. Ancienne*, I, 104.

has been made to accurate ideas upon these points.* Even until the beginning of the seventeenth century, the sun's distance and diameter were supposed to be less than one-twentieth part of what they really are. Keppler, even, in that immortal work in which he announced those laws, which since that time have borne his name, declared† himself unable to fix any close limits; but ten years later, he succeeded by use of Tycho Brahe's observations in approaching much nearer to the true value, although his lower limit was then nearly seven times too small.‡

The determination of the earth's distance from the sun is a problem of peculiar importance, inasmuch as it is the unit in which, by means of Keppler's laws, all the planetary distances are measured. Consequently, all our knowledge of celestial distances (excepting only that of the moon) is closely connected with the value of this fundamental standard of measure; and any addition to our knowledge, which shows any one adopted distance to be too large or too small, demonstrates the same for all the rest. In the year 1672 the astronomer Cassini organized an astronomical expedition for this purpose upon the same general principles as those by which our lamented countryman, Gilliss, endeavored to solve the same problem nearly two hundred years later, that it is by determining the actual distance of Mars, and thence deducing that of the sun. The results of Cassini's expedition gave a value,§ which was erroneous by scarcely more than its fifteenth part, and this value remained accepted for a century more, until in the years 1761 and 1769 the rare phenomenon known as a transit of Venus took place, and appointed the means for a still sharper determination.

The period of revolution of a planet depends exclusively upon its mean distance from the sun. The discovery of Keppler, known as his third law, was this: that the times of revolution for any two planets are in the ratio of the square roots of the cubes of their mean distances. Thus since the times of revolution of the planets are easily determined, we may readily learn the ratios of their mean distances to that of the earth,—or, in other words, their distances from the sun, calling that of the earth unity. This we already know, for all the planets, with very great precision; but when we

* *U. S. N. Astr. Expedition*, Vol. III, pp. lxi–lxvii.

† KEPPLER, *De Motibus Stellæ Martis*, p. 71.

‡ KEPPLER, *Epitome Astr. Copernicanæ*, pp. 478, 486.

§ *Memoirs de l'Acad. Roy. des Sciences*, VII Pt. 1, p. 233.

desire to express the same values in miles, or any other known standard of measure, the case is otherwise. An accurate knowledge of any one planetary distance would give us that of all, and to obtain such knowledge the simplest (and until recently the only method known) was by measuring the parallax of a planet.

What is the parallax? A technical name for a very simple idea. It is the difference of direction in which the same object appears from different points of view. Every surveyor uses it for determining heights and distances; indeed, it is only by this means that the distance and dimensions of inaccessible objects can ordinarily be determined. The first principles of geometry teach us that, provided we know any two angles in a triangle, and the length of one side, we can compute the length of the other sides. If we wish to find the distance of a steeple or other landmark, from a given point, we have but to select some other point whose distance and direction are known, and then to measure the direction of our object from each of these points. Its distance from either of them then becomes a matter of easy calculation. Now, it is clear that the nearer an object is, the greater will be the variation in its direction for a given change in the point of view. For an object only one mile distant, the parallax will be twice as large as it would be were this object two miles off, and the larger the angle, the greater are the facility and accuracy with which the corresponding distance can be found. Therefore, in order to obtain the sun's mean distance from the earth, we desire to know its parallax, and to obtain this latter we measure the parallax of some planet. Those planets which approach nearest to us, and are therefore most available for this purpose, are *Venus* and *Mars*. When Mars is at his least distance, this is not much more than one-half that of the sun, and the least distance of Venus is but little more than one-half as much as this, or about one-quarter part that of the sun; so that Venus would afford twice as great facilities as Mars, were the opportunities for measurement equally favorable. But this is not the case. The orbit of this planet being inside that of the earth, Venus always appears to us quite near the sun, and during the hours of starlight is always low in the heavens, a disadvantage which far outweighs the benefit of its greater proximity. We have seen that the parallax of an object from the two ends of a known base-line gives us at once its distance from either end. For astronomical purposes it is more convenient to deal with the sun's parallax than with his distance. In speaking

of the sun's parallax, that parallax is always understood which corresponds with the earth's radius as a base line, so that this and his distance are convertible terms. Now, the distances of Mars and Venus from the sun are very well known in terms of the earth's mean distance, which is called the astronomical unit, and our knowledge of the orbits in which they move is so thorough that it is easy to compute the distance of either planet from the earth at any moment, so far as it is expressed in astronomical units. Let us but determine the same distance for either planet in miles, or some other known measure of length, and the length of the astronomical unit is thereby established. This is what is called determining the solar parallax.

For this reason Cassini, in order to determine the sun's parallax, organized the expedition for observing that of Mars. One astronomer, Richer, went to Cayenne, in the French colony of Guiana, and there observed the planet (1672–3), while the other made simultaneous observations at Paris, and other places in France. The distances from Cayenne to the French points of observation were easily obtained, and proved sufficient to produce a difference of about 25″ in the apparent position of the planet in the sky.

If in the diagram the true place of Mars be at M, while A and B represent the positions of the observers, the astronomer at A would see the planet as though it were at *a*, while to the latter it would appear at *b*. The angle between these two positions measures the apparent length of the line A B, as seen from M; and knowing the true length of this base line we may easily calculate the distance.

On Richer's return to France, the various observations were computed, and their results compared, and from these Cassini found* that what is usually called the sun's parallax (*i. e.* its difference of direction for observers separated by just one-half the earth's diameter) to be 9·″5, and that the true value could not be larger or smaller than this by so much as 1″. The value was accepted by astronomers, as I have said, and used in their computations for nearly a century previous to the transits of Venus in 1761 and 1769.

*Cassini, *Observations astronomiques et physiques faites en l'isle de Cayenne par M. Richer.* Paris, 1679. Mem. de l'Acad. des Sciences, VII, Part 1, p. 233.

(To be continued.)

ABSOLUTE SYSTEM OF ELECTRICAL MEASUREMENTS.

BY JOSIAH P. COOKE, JR.

1. *Introduction.*—The great improvements in the methods of electrical measurement, which have been made within a few years, and to which the success of ocean telegraphy is chiefly due, we owe, in no inconsiderable measure, to the labors of the Committee on Electrical Standards of the British Association for the Advancement of Science. This committee, composed of the most eminent electricians of England, have not only constructed an absolute standard of resistance (the Ohm), but they have also, by their public influence and individual investigations, very greatly promoted the recent rapid advance of electrical science. Since the new units of the Association are rapidly coming into universal use, and as no detailed account of the new system is readily accessible to American students it has been thought that the following analysis of the subject would be acceptable to the readers of this *Journal.* The following pages have been compiled chiefly from the Report of the British Association for 1863. A knowledge of the elements of electricity is assumed and the well-known laws of electrical currents are made the basis of the demonstrations which follow.

Electromagnetic System.

2. Ohm's law.

$$C = \frac{E}{R}, \qquad . \quad . \quad . \quad . \quad . \quad . \qquad [1.]$$

where C = strength of current.

E = electromotive force.

R = resistance.

These elements should be referred to such standards that the unit electromotive force must produce the unit current in a circuit of unit resistance. Otherwise we should be obliged to introduce into all calculations, some useless and absurd factor.

3. Faraday's law.

$$Q = C\,t, \qquad . \quad . \quad . \quad . \quad . \quad . \qquad [2.]$$

where Q = quantity of electricity.

t = time (in seconds) during which current flows.

Hence the unit of quantity must be that quantity of electricity which is conveyed by the unit current in the unit of time.

4. Joules law.

$$W = C^2\,R\,t, \qquad . \quad . \quad . \quad . \quad . \quad . \qquad [3.]$$

The work done by a current (*e.g.* in generating heat) is pro-

portional to the square of the current, to the resistance of the circuit and to the time during which it acts.

The heat generated by a current of known *strength* in flowing through a known *resistance* during a known *time* can be accurately measured. The mechanical equivalent of heat is well known. The unit of heat being taken as the amount of heat which will raise 1 gramme of water from 0° to 1° C., the mechanical equivalent of this unit is 4157·25 absolute units of work, or 423·8 metre-grammes.*

Hence this equation gives us the means of connecting directly the system of electrical measures with the fundamental units of time, space and weight. In order to make our electrical measurements consistent with the metrical system, we should choose our units such that the unit current in flowing through the unit resistance, should do work equivalent to the unit of work in one second. The units of C and R must then be so taken that $t \times R \times C^2$ shall always give the value of the work done in metrical units. This, however, is consistent with various units, only if either of the two is chosen arbitrarily, the other is fixed by the condition given. Further, when the units of R and C are fixed, the unit of E is also fixed by [1].

Corollary.—By substituting in [3] $Q = C\,t$, and then $\frac{E}{R} = C$ (from [1] and [2]) we easily deduce.

$$W = Q\,E, \qquad \qquad [4]$$

that is, the work done is measured by the quantity of electricity multiplied by its fall of tension. Hence, in our system, the unit quantity falling in tension the unit of electromotive force will do the metrical unit of work.

5. Magnetic Law.

It is well known that an electric current exerts a force on the pole of a magnet in its neighborhood. This effect is a purely mechanical phenomenon, and must be measured by the ordinary mechanical units. The unit of force is that force which imparts to one gramme of matter the velocity of one metre in one second. The force exerted by a current on a magnetic pole has been found to be:

(1) Proportional to the strength of current, or C.

(2) Proportional to the strength of pole, or M.

* The absolute unit of work is the unit of force acting through one metre. The force of gravity acting on one gramme of matter exerts 9·8 units of force. Hence one metre-gramme equals 9·8 units of work.

And if the conductor be at all points equidistant from the pole, or in other words, be bent in a circle with a radius, K, the force is also

(3) Proportional to the length of conductor, L.

(4) Inversely proportional to the square of the radius, K^2.

Moreover, it is affected by no other quantities. Hence we have,

$$F = \frac{C\,L\,M}{K^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad [5]$$

Here L and K are lengths in metres; M, or the strength of magnetic pole, is measured by reference to the unit magnetic pole, which is the pole that, at a distance of one metre, repels a similar and equal pole with the unit force. F is measured in units of force defined as above.

Thus, by this equation, the value of C may be referred directly to the fundamental mechanical units. The unit current must be that which, in a unit length, produces the unit force on a unit pole at the unit distance, and this unit is called the *electro-magnetic absolute unit.*

Corollary.—We may easily bring [5] into a form in which it is more useful. One pole of a magnet can never practically be separated from its opposite; and we must next consider the action of a current on a magnetic needle. In order to make the conditions as simple as possible, we will assume that the needle is very short, and in all its motion is enclosed within a coil of conducting wire. A current flowing through such a coil creates within the coil a magnetic field.* The directions of force † in this field are all parallel to the axis of the coil, and the intensity ‡ of the field is uniform throughout the whole space within the coil. We will further assume that the coil is placed in the magnetic meridian, and that a current passing through the coil deviates the needle from the meridian by an angle, *d*. It is easy to see that the forces acting on the two poles, and tending to turn the needle, would be as above, each equal to $F = \frac{C\,L\,M}{K^2}$.

* A magnetic field is any space in the neighborhood of a magnet.

† The direction of the force at any point of a magnetic field, is the direction in which a pole would be urged, or which a magnetic needle would take if suspended at that point.

‡ The intensity of the field, at any point, is measured by the force which the unit pole would experience at that point.

(To be continued.)

Bibliographical Notices.

The Life and Letters of Faraday. By Dr. Bence Jones. 2 Vols. Philadelphia: J. B. Lippincott & Co. 1870.

It is seldom that we enjoy so great facilities for acquainting ourselves intimately with the character and labors of any man as are afforded in the two volumes now before us. It is seldom that any man's life is so pure that it can be wholly revealed by the friends who are his biographers, and that naught need be extenuated and naught concealed. It is seldom that we rise from the perusal without a feeling of regret for frailties and imperfections intermingled with our pleasure.

In all these respects, this biography of Faraday is exceptional. We are made acquainted with Faraday during his periods of youth and manhood and decay. We learn to know him successively as the imaginative apprentice lad, the inquisitive student, the ardent lover, the laborious experimenter and the profound philosopher. In his earliest letters, we see him casting about for every opportunity of improvement, and seizing with avidity every topic which is presented to him for thought and investigation. When he has found that path for which his genius fitted him, he begins to advance with a firm and careful step. He labors to improve his style of composition, and never suspends that labor until he becomes a master of simple, terse and harmonious language. To improve his delivery, he studies critically the pronunciation and accent, the emphasis and gestures of noted actors, elocutionists and lecturers. He employs his friends to become his rigorous censors, and begs them to note his defects, and unreservedly acquaint him with them. He endeavors to ascertain, and devises means to satisfy, the wants of the youngest and most ignorant of his auditors. His labors are crowned with complete success, and children and men who had grown grey in the pursuit of science, the casual listener and the close student, all go away from his lectures charmed and instructed. With untiring industry he fills his note-book with thoughts which might serve to adorn or illustrate his lectures, and with suggestions which might animate and direct his experimental labors. His energy is ever active in putting to severe test the theories he has formed, and his care is extreme in noting down the minutiæ and results of his experiments. With each successive year he mounts

to a higher plane of investigation and widens his field of view. He arrives at exalted conceptions of the nature and operation of the physical forces, and conceives of profound and intimate relations between them. The discovery of the relations between magnets and electric currents, between electric currents themselves, and between chemical and electrical units of force resulted, and so many new sciences were born—sciences which, even in their infancy, have conferred inestimable blessings upon mankind.

Faraday was happy in many things. He was happy in being born in an humble station, so that every onward step in life was a surprise and delight. He was happy in the capability of feeling a pure and ardent love. He was happy in that, while possessing a keen imagination and fertile invention, he had also such skill in manipulation, that with him success or failure was sure demonstration of the truth or falsity of an idea. He was happy in having so kind and loving a heart, that even all his honors could not create for him lasting enemies or estrange from his friends.

His life was a constant progress. In his youth, in the development of his powers of observation, his readiness of expression and his facility of experiment; in manhood, in his grand and comprehensive generalization. And as the qualities purely intellectual began to wane, those of heart and soul, which, until then, had been somewhat obscured by the splendor of his discoveries, shone out with a lustre that brightened to the last.

In his philosophy, Faraday ventured out into such dark, outlying regions of thought, that few dared or could follow him. Matter, with him, becomes spiritualized into a congeries of force-centres. Ether is a medium too inert and gross to transmit the mutual influences of worlds and molecules, and he substitutes for it innumerable lines of force which form the warp, while matter, so to speak, is the woof of the universe. Is it wonderful, then, that he deemed it possible to effect with matter transmutation more wonderful than any that ever crazed the brain of alchemist, or that he should ascend from the contemplation of many, to that of a single force which manifests itself variously in all? Not only did he conceive of, but he endeavored to realize by experiment this derivation, and to link gravity into the chain of molecular forces.

But lofty as was his philosophy, it never scaled the height upon which he enthroned his religion. His goodness was such that he shared his priceless discoveries with mankind, and gave them to the enrichment of the world. His intellect was placed at the service of the public, and he toiled for half a century to diffuse and increase our heritage of knowledge.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, June 15th, 1870.

The meeting was called to order, with the President, Mr. Coleman Sellers in the chair. The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting held June 8th, inst., donations to the library were received from the Royal Astronomical Society, London; l'Ecole des Mines, Paris, et la Société Industrielle, Mulhouse, France; dem Oesterreichischen Ingenieur Vereine, Vienna, Anstria, Hon. W. D. Kelley, H. R., Washington, D. C.; The Regents of the University of New York; L. J. Fleming, Chief Engineer of the Mobile and Ohio Railroad, Mobile, Alabama; William Sellers, Esq., George Davidson, Esq., C. E., George W. Conarroe, Esq., and the Board of Health of the City of Philadelphia.

The various standing committees reported their minutes. At the request of the President, Mr. Robert Briggs gave some account of the progress in various manufactures observed by him in a late visit to England.*

The report of the resident Secretary, on novelties in science and the mechanic arts was then read.

Under the head of new business, a letter was read from Prof. Morton, as follows:

PHILADELPHIA, *June* 15*th*, 1870.

To the President and Members of the Franklin Institute.

GENTLEMEN:—Having accepted a position in a distant city, which necessitates my removal from this vicinity, it is with regret that I now tender my resignation as Resident Secretary of your Institute, an office which your kind and generous support has rendered it a great pleasure for me to hold. It would be impossible adequately to express my sense of your unvarying kindness, or to portray the agreeable impressions which my past relations with this society calls up in my mind; but I hope and purpose by various means, which may continue or will come to be in my power, to demonstrate my abiding sense of these things, and my lively interest in this venerable and useful institution.

With renewed expressions of thanks, I remain,

Respectfully yours, HENRY MORTON.

* An abstract of Mr. Briggs' remarks will be found at page 73 of this volume of the *Journal*.

Mr. Robert Briggs moved that the resignation of Prof. Morton be accepted, and said: "It is with great regret that he made the motion, and, in doing so, he wished to accompany with the acceptance of Prof. Morton's resignation, a vote of thanks for the eminent obligations under which the Professor had placed the Institute during the past six years of his connection with it.

"The assiduity which he had shown in advancing its welfare, the skill and ability with which he had, step by step, awakened the members to an estimation of the utility of its purposes, the share he had taken in instructing the members in its meetings, the furtherance of the objects of the Institute in other cities and in foreign lands, had been the noteworthy characteristics of his direction. Besides these successes in administration, he had performed a yet more valuable service for the Institute, in the establishment of the present position of the *Journal* as the leading engineering paper of the United States. An institution like our's lives in its record, much if not most of its valuable additions to science are the results of study, and are not, except to special audiences, suited for oral communication. The practical man has already learned, that often what he wishes especially to know, has been studied and discussed and is in print, and if his steps lead him into regions where he finds no footsteps, the route is what it is desired to learn in order to describe and point out the path for future travelers. The record of an institution like our's is worth far more than any popular meetings. Under the editorship of Prof. Morton, the *Journal* has reached an excellence of original articles, which its warmest friends hardly expected it possible to attain."

He therefore moved that the resignation of Prof. Morton be accepted, and, also, that a vote of thanks be entered upon the record for his unremitting labor and care for the interest of the Institute and its *Journal*, whilst he has so satisfactorily filled the office of Secretary.

Mr. Hector Orr seconded the motion of Mr. Briggs, with expressions of sorrow and good-will to the retiring Secretary.

The resignation was then accepted; and the President stated that Prof. Morton had consented to continue his charge of the *Journal of the Franklin Institute*, which had achieved so desirable a position under his management.

The President then appointed Dr. William H. Wahl as Resident Secretary, in the office vacated by Prof. Morton, according to Article VII., Sect. 3, of the Constitution.

The meeting was then, on motion, adjourned.

W. H. WAHL, *Sec. pro tem.*

Contents for August, 1870.

Illustrations—One Plate and Fifteen Woodcuts.

THE

JOURNAL

OF THE

Franklin Institute,

DEVOTED TO

Science and the Mechanic Arts.

EDITORS

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AND

W. H. WAHL, PH. D.,

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Vol. LXXXX.—No. 536.

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Vol. LX.—SEPTEMBER, 1870.—No. 3.

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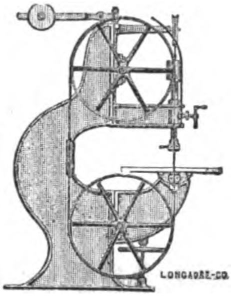

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OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LX.] SEPTEMBER, 1870. [No. 3.

EDITORIAL.

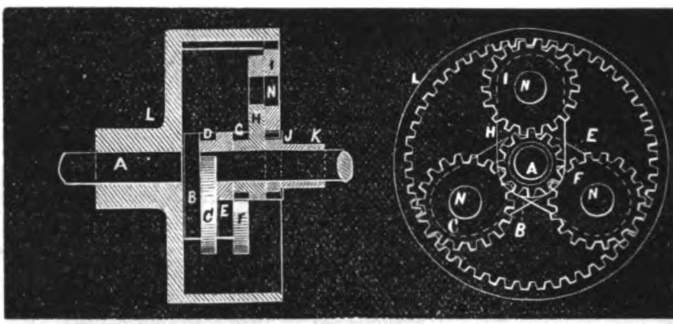
ITEMS AND NOVELTIES

Goodwin's Gear.—The enclosing case L having internal teeth is fixed. The shaft A turns freely in the hub of the case and has secured to it an arm B like a crank, with pin N, upon which freely turns a cog-wheel C. This wheel gears into the teeth of the case and also into a pinion D, which is fastened to an arm E loose on shaft A, but which also carries a pin N and wheel F, all similar to B, N, C. Wheel F gears into the teeth of case L, also into teeth of wheel G, which is secured to an arm H loose on shaft A, carrying a pin N and wheel I, all similar to B, N, C, and again wheel I gears into teeth of case and into pinion J on a sleeve K, which turns freely on shaft A.

The case L has 48 teeth, the wheels C, F and I, have each 18 teeth, and pinions D G and J have each 12 teeth.

If the pinion J be turned by turning the sleeve K, setting all the wheels in motion, it will be found that 125 revolutions of J will be required to turn the shaft A once round, each pinion making 5 turns to one of the cranks to which it connects.

This wheel work may be applied in many ways to the feed-gear of machine tools, where a slow motion is wanted in a small protected space. It is plain that with a deeper case any number of cranks and pinions may be placed in similar relations to the gear as those shown, and a change of speed corresponding to the numbers 5, 25, 125, 625, 3125, and so on, may be obtained.



The cranks all being loose on the shaft may be slipped off at pleasure, and the end pinion J placed in gear with any wheel I, F and C, thus making a corresponding change in the speed of A.

There are other applications of this wheel-work, as, for instance, that of hoisting machines, driving the cutter bar of harvesters by reversing the motions &c., &c. It was patented by Wm. F. Goodwin, Dec. 31, 1867, Mar. 17, 1868 and Aug. 18, 1868. J. H. C.

Reffelt's Calculating Machine.—The machine, of which engravings are seen accompanying, is capable of performing the four fundamental operations of arithmetic—addition, subtraction, multiplication and division.

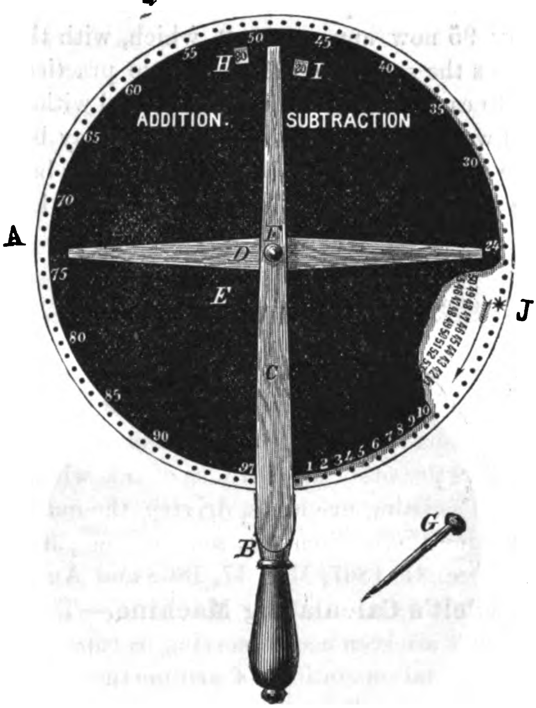
The engravings give views of opposite sides of the instrument, addition and subtraction being performed on the side shown in Fig. 1, and the converse operations of multiplication and division on that shown in Fig. 2.

B is a bifurcated handle; the bifurcations C extending up each side, and forming with the pieces D crosses, to which the stationary disks E are fixed. Between these stationary disks is a revolving disk, which, when set in motion by the style G (Fig. 1) turns

on a central point F, while the handle B is held in one hand of the operator, this style is held in the other, and is inserted in one or other of the small holes in the outer edge of the revolving disk, as will be hereafter explained. The fixed disks E are smaller than the revolving disk, and the number of the holes in the latter is 100, all equally distant from one another.

On the addition and subtraction side, the fixed disk E has marked on its outer edge numbers from 1 to 100, inclusive, placed at equal distances from each other, only the first ten of them being drawn in full in our engraving, the rest being indicated in fives on account of limited space.

Fig. I

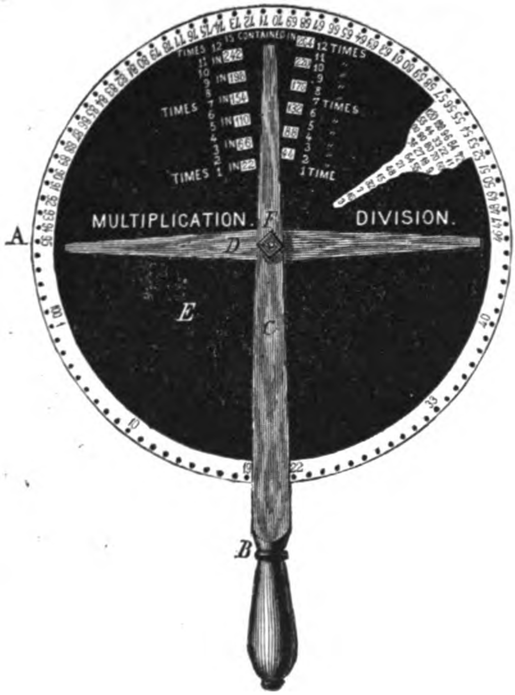


Upon this side of the revolving disk are two concentric rows of numbers, progressing in opposite directions from 1 to 100 inclusive, portions of which are shown where a part of E is broken away. As the revolving disk is turned by the style, the numbers in the outer row appear successively at the aperture H in the disk E and those in the inner row at the aperture I.

Suppose, now, it is desired to add 6 to 7. One of the holes J to which the style is applied, is conspicuously marked. The style being placed in this, the revolving disk is turned in the direction of the arrow until the style is brought flush with C, when 0 appears at each of the apertures H and I. The style being now placed in the hole at 6, the movable disk is rotated until the style stops at C, which brings the number 6 to view at the aperture H. The style

is then withdrawn, and again inserted in the hole next to 7, and carried back to C, which brings 13, the sum of 6 and 7, to view at at H. Two columns of figures can be operated upon at once, as it is just as easy to add 36 to 47, as to add 6 to 7; and by making a mark or tally every time a hundred is passed, the addition may be carried to any extent, thus: 70, 81, 96, 48 would be added in the following manner, J being first brought to C. Carry the style from C to 70, and bring that number to C; do the same with 81, and make a tally mark for the hundred passed; 51 now appears at H. Next carry 96 round to C, and tally for the second hundred passed; 47 now appears at H. Next carry 48 round to C; 95 now appears at H, which, with the two hundreds tallied, makes the sum 295. A very little practice will enable the operator to carry the hundreds in the mind without recording them. In this way two columns of any length may be added simultaneously. The sum of each successive two columns being set one place below the preceding sum, and two places to the left, and the several sums added, enable the machine to be applied to adding any number of columns.

Fig 2.



Subtraction can be performed upon the same face, by bringing the conspicuously marked hole, J, opposite to the larger number, inserting the style at the lesser, and bringing the disk round to C, when the remainder will appear at the aperture I. As with addition two columns of numbers can be subtracted at once, and in proceeding to the next left-hand figures, if any, one

mentally adds one (as in ordinary subtraction) to the lesser number, if the upper number is smaller, than in the previous operation.

On the multiplication and division side, Fig. 2, the movable disk has upon it concentric rows of numbers, portions of which are shown by the breaking away of a part of the fixed disk E. The inner row contains the numbers from 1 to 100; the next the numbers from 2 to 200, which are divisible by 2; the next those from 3 to 300, divisible by 3; and so on to the outer concentric row, which contains the numbers from 12 to 1,200, divisible by 12. As the revolving disk is rotated by the style in the same direction as in adding or subtracting, the numbers in these rows are successively brought under apertures placed at the right and left of C, at the upper part of the fixed disk E. The fixed disk E has upon it a row of figures from 1 to 100 inclusive, progressing in a contrary direction to the numbers on a clock dial. The numbers are so arranged, that when any one of them is brought by the rotation of the revolving disk flush with the bar C, the products obtained by its multiplication into the odd numbers from 1 to 11 inclusive appear at the right-hand series of apertures, the smallest product in each series of apertures, being the inner one, and each series of products increasing regularly outward.

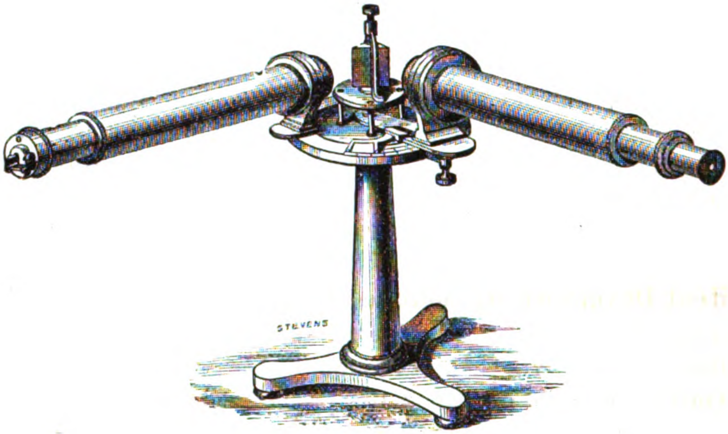
It is evident, therefore, that the multiplication of any number from 1 to 100 inclusive, by any number from 1 to 12 inclusive, is performed by bringing the multiplicand flush with C, by the use of the style, when the required product will appear in the aperture adjacent to the multiplier. Conversely, the quotient from any number from 1 to 1,200 inclusive, exactly divisible by any number from 1 to 12 inclusive, divided by any number from 1 to 12 inclusive, is found by bringing the divisor flush with C, when its quotient will appear opposite the dividend, which latter will show itself at one or the other of the apertures.

The agency for the machine is in the hands of E. Steiger, 22 and 24 Frankfort Street, New York.

Browning's Spectroscopes.—Messrs. Bullock & Crenshaw.—Mr. Browning of London, has recently effected quite a number of alterations and improvements in the spectroscope. The instruments figured here are manufactured by him, and will at once be seen to differ in a number of particulars from those ordinarily in use. They are furnished with one and two prisms, and the third tube with the illuminated scale is altogether dispensed with. Of

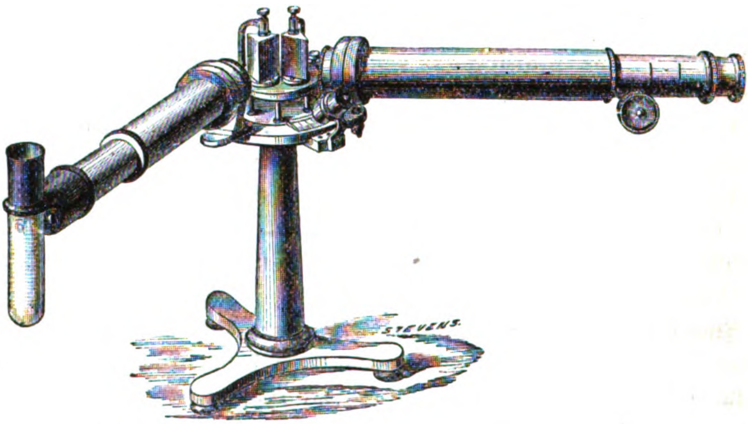
the two tubes, one is fixed, while the other (the telescope) is movable about the circumference of the horizontal plate which bears them and the prisms, which are of dense flint glass.

Fig. 1.



The positions of the lines are measured by the distances through which it is necessary to carry the movable tube, in order to bring each of them successively into the centre of the field of view. By means of dividing wires with which the telescope is furnished, this

Fig. 2.



is accomplished to a nicety; while the readings are made from a graduated scale upon the rim of the plate. An accompanying vernier permits of any desired accuracy in this respect, and a screw-

clamp conveniently placed, holds the glass firmly in place when the desired centering of the line under examination has been attained. The positions of the lines relative to each other, or to any one taken as an arbitrary standard of comparison, can be determined in this way, with the greatest accuracy and convenience.

The working of Mr. Browning's instruments has been highly praised abroad, though, to the best of our knowledge, they have as yet been very little introduced in America. We were favored, at the establishment of Messrs. Bullock & Crenshaw, of this city, with an opportunity of examining several of them, of which the accompanying engravings are good illustrations, and were particularly impressed with the unexceptional excellence of the fitting and finish of the various parts.

Heat Developed by Sound.—In a late number of the *Philosophical Magazine* (253), we find an interesting record of a research in this direction by Dr. E. Warburg.

The author remarks that William Weber had pointed out in the 24th volume of *Poggendorff's Annalen*, that the resistance of the air would not account for the loss of motion in vibrating bodies, and that some specific difference in their structure independent of their density must be the cause of the great diversity in this respect exhibited by various substances. The author then proceeds to remark that some of the vis-viva being therefore consumed in interior work it is natural to suppose that it is there converted into heat. The amount of motion so converted into heat will be greatest in those bodies which like lead soonest cause the sound to fade away.

The phenomenon of deadening produced when certain bodies are attached to sonorous ones, leads to a like conclusion.

Thus a tube of lead attached to one of glass soon destroys the sound of the former, while a tube of steel or brass has very little effect. Hence it might be expected that more heat was produced in the lead than in the other material.

Repeated experiments made with the necessary precautions proved the truth of this conclusion with a variety of substances. Thus a rod of wax being attached as a prolongation to a glass tube, and a thermo pile brought in contact with various parts of the latter, an astatic galvanometer in circuit with the pile, showed a deflection of 300 divisions in the heat direction at a node and of 50 at a loup. A lead tube replacing the wax showed 300 to 400 at a

node and 40 at a loup. A thinner lead tube gave 600 for a node. Self-sounding tubes gave like results as also did wires and rods of various substances appropriately disposed; the order of decreasing thermal effect being copper, iron, steel, wood. India rubber, remarkable for its deadening properties gave a heating indication of 1000 divisions and a thermometer showed an actual increase of 2° Cent. These experiments were made with longitudinal vibrations. Similar ones conducted with transversal tones gave analogous results with the exception that the rise in temperature in the loups was here as great as at the nodes.

The amount of heat produced in various bodies seems to be in an inverse proportion to their rates of transmitting sonorous vibrations.

Motion of Camphor on the Surface of Water.—Most of our readers have no doubt witnessed the curious effect produced when some fragments of camphor are scattered upon the surface of a vessel containing clean water. Each minute fragment begins an independent rotary and progressive motion on its own account, which will continue until all the camphor has disappeared by solution and evaporation, unless some oily matter should be introduced, in which case the motion is at once and permanently arrested. This simple experiment, as we learn from an article by Dr. Chas. Tomlinson,* has been, since 1686, the subject of philosophic discussion and investigation, and it would seem that it has been reserved for the eminent physicist M. Plateau, in a memoir last year, *couronné* by the Royal Academy of Sciences of Berlin, to give the final and full elucidation to the difficult problem.

Passing over the labors of no less than sixteen savants who have contributed more or less to the knowledge by which the question has at last been solved, we will come at once to the final conclusion.

All liquids have a definite cohesive force between their particles which, while equilibriating itself by equality of arrangement on all sides with reference to any point in the interior of the mass, has, on the surface, the effect of producing an elastic envelope composed of the surface layer of liquid particles.

When a liquid contained in an open vessel has established itself in a state of equilibrium as regards its free surface, that surface is in a state of tension due to the strains developed by gravity in combination with the adhesive attraction of the containing vessel,

* See *Philosophical Magazine*, Vol. XXXVIII., p. 409.

which may be roughly illustrated by the case of a bladder or thin rubber bag filled with water, and then put into a bowl or dish which it is capable of filling.

The tension and strength of the rubber sack or moist bladder, here rudely represent the strain and cohesion of the surface layer of particles in the free liquid.

Direct experiment proves that the solution of camphor in water greatly diminishes the cohesive power of the latter.

It is then easily seen that in the experiment first described, the cause of the phenomenon becomes evident when the above facts are before us.

The camphor dissolving unequally at different points, causes the surface film to be torn away at these parts by the surrounding particles and a fresh surface is formed by material from beneath, only to suffer a like treatment in its turn. The currents thus produced occasion the observed motions of the camphor. Oils arrest this motion by spreading in a thin film over the water, and so reducing its tension to an equality with the camphor solution.

Again, it is found that a fragment of camphor placed on a little raft of mica will also rotate. Here it is the vapor escaping from the camphor which produces the effect, and the influence of vapors in this respect may be well studied by dusting the surface of water with lycopodium, and then holding a fragment of camphor above it, or even a drop of ether which has a like power of diminishing the cohesion of water when dissolved in it.

The memoir above quoted contains numerous ingenious experiments by which every point in the theory is maintained, but our space is too limited to allow of a further notice at this time.

The U. S. Naval Observatory, we are gratified to learn, will come into the possession of the $40,000 refractor of Mr. A. Clark.

A new Determination of the Atomic Weights of the Earthy Metals.—Prize subject.—The philosophical faculty of the University of Göttingen offers the following as the subject of a prize essay.*

Theories upon the constitution of matter have yielded no lasting results. An induction from the results of many exact investigations is needed, in order to answer the question, so important for philosophical interests of the most diverse character, whether the

* Ber. der deutsch. Chem. Gesell. Berlin, May, 1870.

known chemical elements are to be regarded as originally different substances, or as derived in some manner from the same fundamental material, and how, in both cases, the formulæ which would express their characteristic properties are to be arranged as members of a series. The most important preface to this induction is the exact determination of the atomic weights of these elements.

Although the classic investigations of J. S. Stas have lately determined the atomic weights of chlorine, bromine, iodine, potassium, sodium, lithium, lead, silver, sulphur and nitrogen with extraordinarily great accuracy, and with the greatest possible avoidance of constant errors, and have given a computation of the most probable errors of the final results, nevertheless these works include only about one-sixth of the elements, which are known at present, while the atomic weights of the other elements have different degrees of certainty.

For these reasons, a prize of 500 thalers, gold, in Friedrich's d'or is offered, until the 31st of August, 1872, for the best, and of 200 thalers for the second best essay, containing a new and entirely exact determination of the atomic weights of the earthy metals. The limits of error of the results obtained must be given, and a critical revision of the previous scientific investigations in this direction. The faculty would gladly see the question decided at the same time, whether the hypotheses of Prout and Dumas should be rejected, or the differences between these hypotheses and the observations allow themselves to be explained by adequate chemical or physical considerations. A. R. L.

A New Volumetric Method of Estimating Grape Sugar.—K. Knapp.—A late number of *Chemical News* contains amongst its news from foreign sources the following abstract of the above paper:

"This method is based upon the fact that an alkaline solution of cyanide of mercury is completely reduced to the metallic state by grape sugar. The process is executed as follows:—10 grammes of pure and dry cyanide of mercury are dissolved in pure distilled water. To this solution is added 100 c.c. of caustic soda solution (sp. gr. 1·145) and as much distilled water as will be required to make the bulk 1000 c.c. A series of experiments made by the author, brought to light the fact, that 400 milligrammes of cyanide of mercury are, when in alkaline and boiling solution, completely reduced to metal by 100 milligrammes of grape sugar. The titration is done as in Fehling's method:—40 c.c. of the alkaline cyanide solution are boiled in a porcelain basin, and the sugar solution (not stronger

than a half per cent.) is added until all the mercury is precipitated. In order to test the course of the operation, a single small drop of the fluid is put upon a piece of Swedish filtering-paper stretched over the mouth of a small beaker-glass, which contains a little sulphide of ammonium.

As long as any cyanide remains undecomposed a brownish spot will appear. The author states that with a little practice, even 1—10 c.c. of the above dilute sugar solution can be readily estimated.

On Edible Earth.—By Prof. C. W. C. Fuchs.—(From the Verhandlungen des natur-historisch medizinischen Vereins zu Heidelberg, Vol. 5, No. 3.)

To the list of the earth-eating people the Javanese must be reckoned; a fact brought to our knowledge by Alex. von Humboldt. From the specimens which I have had the opportunity of seeing, it is to be inferred that earths of very different external appearance, and of different character are eaten. One deposit of such edible earth, possessing an intensely red color, exists in the neighborhood of Sura Baja, between strata referable to the time of the latest tertiary.

This earth is formed into thin cakes, having a diameter of from 1–1½ inches; it is then dried over an open fire, and in this condition is brought into the market. It is perfectly smooth to the touch, and is composed of materials in the finest state of subdivision. By a chemical analysis, to which I subjected it, after removing the thin stratum of soot, which settles upon it during the process of drying over the fire, I convinced myself that it does not contain the slightest trace of an organic substance. The analysis gave the following result

SiO_2	50·63
AlO_3	21·32
FeO_3	10·47
H_2O	12·97
CaO	2·40
MgO	0·33
K_2O	1·02
Na_2O	0·23
	99·37

Of the water, 6·36 per cent. was driven off below red heat. The remaining 6·61 per cent. disappeared only when the test portion was heated to bright redness. From the analysis it is apparent that the earth consists of a clay rich in iron; in which is still retained small quantities, yet undecomposed, of the minerals from which

it derived its origin. In this way the trifling per centage of potassa and soda may be accounted for. Taking away the accessory alkalies, and so much of the silica as they demand, there remains behind a clay of the formula:—

$$H_2 (Al, Fe) Si_2 O_8 + H_2 O.$$

Humboldt suggested, that the probable explanation of the earth-eating habit, might be found in the desire to fill the stomach, and thus, in a measure, to allay the pangs of hunger. This view of the subject may be satisfactory when applied to those rude people who devour it in great quantity; but it will not apply to the case of the Javanese, who make this use of but trifling quantities. With these, it is much more probable that the physical properties of the earth alone, are sufficient to furnish the cause we are seeking.

Upon rubbing it, not the slightest grittiness is perceptible, and on being moistened with water it forms a smooth and unctious mass. The enjoyment derived from eating it seems to reside in the similarity of the sensations it produces, with those derived from the eating of fatty substances. In many parts of Würtemberg the quarrymen have the habit of eating the smooth, unctious clay which collects in the fissures of the rocks. The term "Mondschmalz," which they apply to it, would seem to refer to the enjoyment they experience in the process of eating.

Quantity of Carbonic Acid Contained in the Air of School-Rooms.—Dr. Breiting.—The author made a series of fourteen experiments, beginning at 7·45 A. M. and continued to 4 P. M., in a room of 251·61 cubic metres' capacity, and containing 64 children. The quantity of carbonic acid contained in the air of that room during these experiments varied from 2·21 to 9·36 per cent., while free open air contains $\frac{4}{10000}$ths of that gas; and a quantity of 1 per cent. of the same gas present in air is considered injurious to health.—*Chem. News.*

Refrigerative Effects of the Carre Ice Machine.—The number and the growing importance of those branches of iudustry, in which, during the warmer seasons, a low temperature for certain rooms or houses is required, attach an importance equal to the extent of the interests involved, to every reasonable and well confirmed method by which this object may be attained with greater effectiveness, or at less cost than with the methods now in general use. It is in this connection that we publish the following tables, of the authenticity of which we are fully convinced. They were obtained as the

result of an experiment made for the purpose of determining the comparative refrigerative power of a Carré machine on the one hand, and that of melting ice on the other. In both cases the conditions under which the trial was made were the same, both with regard to place and temperature.

The temperature of a closed room, measuring 3,375 cubic feet, was raised to 80° Fahrenheit by means of a stationary steam heater placed in it. A blower commenced to force cold air into this room from the refrigerating apparatus.

	TIME.					DEG'S.	
At	1·20	when the	thermometer	stood	at	80	Fahrenheit.
"	1·21	"	"	"		76	"
"	1·22	"	"	"		66	"
"	1·23	"	"	"		58	"
"	1·24	"	"	"		53	"
"	1·25	"	"	"		50½	"
"	1·26	"	"	"		48	"
"	1·27	"	"	"		46	"
"	1·28	"	"	"		45	"
"	1·29	"	"	"		44	"
"	1·30	"	"	"		43	"
"	1·31	"	"	"		42	"
"	1·32	"	"	"		41	"
"	1·33	"	"	"		40	"
"	1·35	"	"	"		39	"
"	1·37	"	"	"		38	"
"	1·40	"	"	"		37	"
"	1·44	"	"	"		36	"
"	1·47	"	"	"		35	"
"	1·56	"	"	"		34	"
"	2·05	"	"	"		32	"

During the trial, two glasses, one containing cold, and the other hot water, were placed at the opening of the inlet which conveyed the cold air into the room; the contents of the first were frozen to three-eighths of an inch thick in twelve minutes, while it required but twenty-three minutes to effect the same result with the latter, which had originally been at 140° Fahrenheit.

At the close of the operation, the thermometers of the cooling box indicated fully as low temperatures as at the commencement, proving conclusively that the apparatus could indefinitely produce the same results, It is worthy of note that the steam heater was likewise cooled down to the temperature of the room.

The total amount of steam employed to supply heat, motive power and water for the operation, was equivalent to less than five horse power.

On the following day the same room was heated to 80° and the temperature then lowered to 46° Fahrenheit by melting Portland ice.

The results obtained were as follows:

Time.				Deg's Fahr.
At 2·34	when	1,054	pounds of ice were on the scales the temperature was	80
" 2·38	"	1,045	" " " "	78
" 2·36	"	1,038	" " " "	70
" 2·39	"	1,029	" " " "	67
" 2·43	"	1,024	" " " "	62
" 2·46	"	1,018	" " " "	59
" 2·51	"	1,012	" " " "	56
" 2·58	"	960	" " " "	52
" 3·05	"	948	" " " "	49
" 3·15	"	935	" " " "	48
" 3·22	"	920	" " " "	48
" 3·25	"	907	" " " "	47½
" 3·30	"	900	" " " "	47
" 3·46	"	880	" " " "	46½
" 3·56	"	868	" " " "	46½
" 4·32	"	815	" " " "	46¼
" 4·58	"	760	" " " "	46¼
" 5·00	"	754	" " " "	46

At this last point it would have required such an increased quantity of ice to lower the temperature that the experiment was abandoned.

CHEMICAL ITEMS.—The *Chemical News* contains the following interesting abstracts of papers from foreign sources:—

Amorphous Silica as a means of Fixing Pigments and Dyes.—Dr. M. Reimann.—The author describes at some length, a series of experiments made with the view to apply amorphous silica (as obtained by precipitating a solution of so-called water-glass, silicate of soda or potassa, with an acid, and collecting, washing and drying the precipitate in the ordinary way) for absorbing the solutions of fuchsine, aniline blue, &c., and to apply the colored powder so prepared as a pigment for various materials. The author states that glass, first superficially acted upon by hydrofluoric acid, and next mordanted, as is usual for cotton, assumes, when submitted to the processes in use for dyeing fibre, precisely similar colors as that fibre, and that this effect is caused by the amorphous silica contained in the glass and made active by the hydrofluoric acid.

Preparation of Anthracen.—Dr. J. Gessert.—That portion of the distillation of coal-tar commonly called green grease, and used as wagon and cart-grease, is, according to the author, the material of coal-tar which contains anthracen, and consists chiefly of a heavy oil, naphthaline, and about 20 per cent. of anthracen, which, however, is only contained in coal-tar to an amount of from ¾ to 1 per cent. This semi-fluid grease is first placed in a centrifugal machine, in order to expel, mechanically, as much as possible of the oil; the residue is heated to 40°, and pressed preferably between hot plates. The cake thus obtained (crude anthracen, containing 60 per cent.

of that substance) is purified by boiling with light tar-oil (coal-tar naphtha), or with petroleum naphtha. The pasty mass is again placed in the centrifugal machine, to remove the last traces of heavy oil, and the material next submitted to sublimation. In order to test the green grease for the quantity of anthracen from 5 to 10 grms. of that substance are taken, placed between folds of filtering paper, and pressed between hot plates; the remainder of the substance is repeatedly boiled with alcohol, washed with cold alcohol upon a filter, and next dried and weighed. The fusion point of the mass should be as near as possible 210°. The author says that sulphide of carbon is not well suited for the purification of anthracen, because that substance is too readily soluble in that fluid. 100 parts of alcohol dissolve, when cold, 0·6 parts of anthracen; 100 parts of cold benzole dissolve 0·9 parts of anthracen; and 100 parts of sulphide of carbon dissolve 1·7 parts of anthracen.

Editorial Correspondence.

PERFORMANCES OF ENGINES.

Editors of Journal of the Franklin Institute.

GENTLEMEN:—In attempting to prepare the information for which Mr. Haswell asks, in the February number of 1870, page 86, I regret to find some difficulty in interpreting his first paragraph. As we do not deduce results, *at* a formula; as we do not invent a formula for each particular horse power; and as Mr. Haswell may find the ordinary formula in any steam engineering work, amongst them the justly celebrated "Pocket Book" of his namesake, I fear that I do not apprehend him.

A theoretical formula, with a full explanation of the intermediate work, will occupy much valuable space, but I shall be glad to gratify Mr. Haswell, so far as I can, if that is what he wishes. The ordinary formula, used in working indicator cards, is nearly enough true, and is too well known to need reprinting in the *Journal.*

The questions in regard to the *elements*, being much more clearly stated, are more easily answered.

1. The statements of the performances given in my paper, were, as was mentioned in that paper, collected by other engineers. Usually allowance is made for friction, &c., in reports of performances of engines, and I do not think it has been neglected i

the cases cited; but, presuming that it has been, I am willing to risk doubling that allowance, as there will then be a large margin in favor of the rotative engine.

2. The usual allowance for friction of load is seven per cent. of the net horse power, but five per cent. is probably enough, when the bearings are of the best material and workmanship, and are properly proportioned. The lubricant has much to do with the friction of load, as, below a certain limit, it supports the load; the friction will then vary with the load. Beyond this limit the lubricant will be driven from between the surfaces, and the ratio of load to friction will increase.

The mention of the allowance for friction of load, in the case of the Wampanoag, was accidental rather than designed. I have been accustomed to reports wherein all these deductions are made, when duties are compared, and I did not know that any one had attempted to represent duty by a comparison of total horse power.

3 and 4. The Wampanoag and Ammonoosuc certainly have surface condensers. The surface condenser is an improvement, in marine engines, made for the purpose of avoiding the evils and expenses resulting from the use of large quantities of sea water, of high density, in the boilers. If such an improvement is needed in the Cornish engine, it is the fault of the builders, not a reproach to the rotative engine. We are, however, not writing of the relative efficiencies of condensers, but of complete engines.

On ordinary voyages, sea water must be passed into the boilers, heated, and blown out, to keep the water in the boilers at the proper density, even with surface condensers. Good fresh water can, in nearly all cases, be found for the Cornish boiler. The expense of heating the water blown out, and the injury done to the boilers by the accumulation of scale, are, and should be, generally unknown to Cornish boilers.

The injudicious application of otherwise useful inventions, has helped to reduce the duty of the Cornish engine more than one-half, and compels us to go back twenty years for a lesson in steam engineering.

Cannot some of our builders produce a "true copy" of the 80″ at Fowey Consols? The copy should do about the same duty as the original, under the same conditions, and would be sure to give satisfaction. Respectfully, W. H. G. West, U.S.N.

Talcahuano, Chili, July 1st, 1870.

Civil and Mechanical Engineering.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 113.)

The following article from *Vol.* 3, *for* 1859, *Publication Industrielle par Armengaud aîné*, relates to belts employed for the transmission of power.

"Several years prior to this date, M. Laborde, M. E., presented to the Industrial Society of Mulhouse a paper on the subject of belts, in which he made the following observations:

"1st. The resistance to be overcome must be less than the power required to slip the belt on its pulley.

"2d. The tension must not permanently elongate the belt.

"3d. The tension must not uselessly increase the friction of the shaft bearings.

"4th. The belt must be flexible, in order to allow of an easy folding in all its parts.

"The first three conditions named are self-evident, while of the fourth it may be said that a belt never requires doubling, but should always be composed of a single thickness of leather.

"The webs of a single leather are extended and compressed in passing over the pulleys without in any way injuring their texture, while the two leathers composing a double belt are subject to such a friction upon each other that their destruction follows rapidly, notwithstanding the numerous points of connection uniting both; it is therefore best to abandon double belts altogether.

"In order to maintain the durability and flexibility of belts it is advised to apply to them, as they need, pure grease, or ordinary grease mixed with tallow, which may be done while they are running. They are apt to slip for a few minutes after greasing, but soon adhere again, and finally drive the better for the application.

"Extended experimental observations have proved the superiority of smooth faced pulleys over such as are rough, or ribbed in the one or the other direction: in that, increased area of surface contact with the belt is presented by the former.

"Upon the above considerations as a basis, M. Laborde develops his formulæ.

"1st. The width of belts must be in direct proportion to the power to be transmitted, while the speed remains uniform.

"2d. The width of belts vary inversely to the speed.

"Consequently the products of the widths and speeds of belts are proportional to the power transmitted by them.

"Experience demonstrated to M. Laborde that a belt 3¼ inches wide, running 533 feet per minute readily transmitted one-horse power of 33,000 foot-pounds, having the usual tension, and without deforming itself, when the pulleys are smooth faced and of equal diameter, in order that the belt may embrace their semi-circumference.

"This is equivalent to 144·35 square feet of belt per minute per horse-power, and 19 pounds strain per inch of width.

"The author has used this rule a number of years, and expresses himself well satisfied with the result.

"M. Carillon, of Paris, a mechanical engineer of no less reputation, employs a rule based upon the following statement:—A belt can transmit 1 H. P., if it have a surface velocity of 96·9 square feet per minute, providing not less than one-third of the circumference of either pulley be embraced.

"Notwithstanding our great confidence in M. Carillon's deductions, believing that in most cases his allowance of driving surface of belts will be sufficient, since in many cases belts are run at a higher velocity, we yet think it preferable to adhere to the base established by M. Laborde.

"The reduction of driving surface may be made with more security by employing well-worked leather, as that of Messrs. Sterlingue & Co., who condense it under the hammer, or that of Mr. Bérendorf, in whose machine it becomes strongly compressed.

"Tables 1 and 2 (not given here) are developed from the following example:—If a belt travel 100 metres per minute, it should be 132 millimetres wide in order to transmit 1 horse-power; which is equivalent to a 5·2 inch belt traveling 328 feet per minute, or in other terms, it is equal to 142·13 square feet of belt per minute per horse power.

"It is easy to understand why the sizes of belts, as indicated by the preceding figures, must be modified in several particulars: firstly, when the pulleys are of very different sizes, or, if expressed in more general terms, when the pulleys are embraced by the belt

less than the semi-circumference, and secondly, when the belt is crossed, or when more than half the pulley surface is encircled.

"M. Paul Heilmann presented very judicious observations on this subject to the Society of Mulhouse, which results are reproduced in the Society's Bulletin, No. 40, 1835, and may be expressed thus:

"The friction of a belt upon a pulley depends:

"1st. Upon the pressure or tightening.

"2d. Upon the number of degrees of contact.

"3d. It is independent of the diameter of the pulley.

"4th. It is independent of the width of the belt.

"It is evident that the less the pulley is surrounded by the belt, the tighter must be the belt in order to transmit a given power, because the power which can be transmitted to the pulley is always less than, or at best equal to, the friction produced on its surface, and if the resistance offered by the machine be greater the belt will slip. Thus the width of the belt has no other purpose than to give it a resistance, a power sufficient to withstand a certain tension without being injured or broken.

"M. Heilmann says that this tension, and with it the width of the belt, must necessarily be an inverse proportion to the numbers as represented in the following table, which table has been calculated after the formulæ and by the aid of the hyperbolic logarithms.

$$\text{“ Friction} = \text{P}\, e \left(\frac{f\,\text{S} - 1}{\text{R}} \right),$$

"In which,

P = resistance to be overcome.

e = base of hyperbolic logarithms, = 2·718.

f = proportion between friction and pressure.

R = radius of pulley.

S = lineal contact of belt with pulley.

"This formula is the one taught in the Mechanical Engineering Department of the Polytechnic College.

"In the table, the first column represents the angle of contact of belt, in degrees and minutes.

"The second column represents the fractional part of the circumference corresponding to the angle.

"The third column shows the ratio between friction and pressure following the angle of contact.

"The fourth column contains the result of the division of the

ratio 0·4670, which corresponds to the half-circumference, by the successive ratios of the friction and the pressure.

TABLE III.

1	2	3	4
° ′			
22·30	$\frac{1}{16}$ = 0·0625	0·0491	9·511
30·	$\frac{1}{12}$ = 0·0833	0·0660	7·075
45·	$\frac{1}{8}$ = 0·1250	0·1005	4·646
60·	$\frac{1}{6}$ = 0·1667	0·1363	3·426
67·30	$\frac{3}{16}$ = 0·1875	0·1545	3·023
90·	$\frac{1}{4}$ = 0·2500	0·2112	2·211
112·30	$\frac{5}{16}$ = 0·3125	0·2706	1·725
120·	$\frac{1}{3}$ = 0·3333	0·2911	1·604
135·	$\frac{3}{8}$ = 0·3750	0·3330	1·402
150·	$\frac{5}{12}$ = 0·4166	0·3763	1·241
157·30	$\frac{7}{16}$ = 0·4375	0·3983	1·172
180·	$\frac{1}{2}$ = 0·5000	0·4670	1·000
202·30	$\frac{9}{16}$ = 0·5625	0·5390	0·866
210·	$\frac{7}{12}$ = 0·5833	0·5674	0·823
225·	$\frac{5}{8}$ = 0·6250	0·6145	0·760
240·	$\frac{2}{3}$ = 0·6667	0·6669	0·700
247·30	$\frac{11}{16}$ = 0·6875	0·6937	0·673
270·	$\frac{3}{4}$ = 0·7500	0·7769	0·601
292·30	$\frac{13}{16}$ = 0·8125	0·8642	0·510
300·	$\frac{5}{6}$ = 0·8333	0·8941	0·522
315·	$\frac{7}{8}$ = 0·8750	0·9551	0·489
330·	$\frac{11}{12}$ = 0·9163	1·0190	0·458
337·30	$\frac{15}{16}$ = 0·9375	1·0515	0·444
360·	1 = 1·0000	1·1522	0·405

"From the preceding observations it will be easy to determine the width of a belt in all cases that may occur in practice whenever the maximal force in H. P. is given, which is to be transmitted and the speed of belt known.

"If the pulleys are of equal diameters all that is needed is to find the width of the belt, in accordance with the examples from which tables 1 and 2 are constructed, corresponding to speed and power required.

"If the pulleys are of different diameters, then use the following:

"Rule:—Determine the number of degrees of contact with the smaller pulley; find in the third table the number in fourth column

corresponding thereto; multiply the number thus found into the width of belt given in tables 1 or 2.

"In all the preceding we constantly admitted the belt of single thickness, and consequently the same power of resistance.

"Although this is generally the case, yet for transmitting small powers at great speed it is better to reduce the thickness and augment the width of the belts, because they will then develop better on their pulleys, which are usually of small diameters.

"In such cases belts of inferior quality may also be employed, by determining their width from a less co-efficient of resistance. On the contrary, for the transmission of great powers at slow speeds, it is advisable to use the thickest possible leathers, in order to avoid great width.

"We have as yet taken no account of the belt's own weight, which in certain cases is to be added, wholly, or in part, to the resistance to be overcome, whilst in others it will have to be deducted from said resistance, but as this has a slight influence on the practical results, it may be left out of consideration.

"Belts should be calculated to meet the maximal resistance, not the average.

Belts of Gut.

"In speaking of belts, it will not be superfluous to announce that an English inventor, Mr. John Edwards, conceived the idea of making belts of gut, prepared in endless flat bands of different lengths and widths, for use on pulleys, and united evenly.

"The filaments of gut are woven into ribbons on looms similar to those used in manufacturing metallic gauze and the joints made by splicing, care being taken to cut or burn the extremities of the interlaced filaments, in order to obtain perfectly united bands. It is known that experiments were made to manufacture belts from fibrous substances, such as hemp and wool, but it is thought up to this date that they will not endure the same wear and tear as leather. The gut was and is yet employed with advantage, in the shape of cords running in grooved pulleys.

Belts of Wool.

"Another patent has been issued in England to Mr. J. Heywood, for a system of belts or bands of wool, which the inventor prepares by soaking in a mixture of linseed oil and rosin. He boils, for instance, $6\frac{2}{3}$ pounds of oil, adds $4\frac{1}{2}$ pounds of powdered rosin, and

agitates the mixture to a perfect union; after having the bands soaked, he submits them to the action of a pair of rolls, and afterwards exposes them to dry, when they are ready for use.

Belts of Gutta Percha.

"M.M. Rattier & Co. introduce, in a great measure, gutta-percha belts which give good satisfaction. They also make these belts with wire-gauze cores, which prevent stretching. Notwithstanding this precaution, we believe it best to employ such belts for light transmission only, with slow speed, and to subject them to slight tensions in order to avoid injury by heating.

(To be continued.)

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

By Col. O. W. Childs, C. E.

(Continued from page 109.)

Harbor of San Juan.

The principal branch of the river, at the point of discharging its waters into the harbor, changes from a northerly to a westerly direction. A short distance above this point there are on the left several islands, between which divergent branches from the river pass a considerable portion of its waters into the more southerly side of the harbor, and on the right, between the harbor and the sea, a mole of sand, varying in width from three to twenty chains, extends westerly about sixty chains; thence gradually curving to the left, bounds the northerly side of the harbor $\frac{85}{100}$ths mile to its termination at a point $\frac{58}{100}$ths mile from the main land, bounding the southwesterly side of the harbor. This natural basin below the entrance of the river has a water surface 1·$\frac{68}{100}$ths mile by 1·$\frac{18}{100}$ths mile in extreme length and breadth, and an average of about $\frac{45}{100}$ths mile by $\frac{95}{100}$ths mile in length and width, covering an area of 881 acres, of which about 250 acres has a depth of eighteen feet of water, with an extreme depth of 26 feet at low tide.

This harbor is connected with the sea by a channel, at the time of making the soundings, September, 1851, 24 feet in depth, and about 1,300 feet in width. On the outer side of the channel, and about 800 feet below the termination of the natural mole, a sand bar, with a top width of 350 feet, rises to within from 5 to 8 feet of the surface of the sea, and being subject to the action of the waves and the currents of the river, is changeable in its position. The frequency and extent of its changes were not, owing to the want of observations during the various stages of flow in the river, ascertained; it has not, however, been such as to prevent the largest

steamers plying between Europe and the United States, and Chagres, from passing, and, so far as is known, without difficulty, through this channel to and from the harbor. To give greater stability and uniformity of depth in the channel, the expense of constructing two arms of a jetty or breakwater is included in the estimate, the one to extend from the termination of the mole before described 330 feet, and the other at right angles from the main land 1,188 feet towards the channel, leaving an entrance 1,584 feet in width. This work, when constructed, will, as is believed, with the requisite light, at all times furnish to vessels a practicable and safe communication between the harbor and the ocean.

The artificial portion of the harbor is to be formed by a cut 150 feet in width, to extend from the foot of the lower lock obliquely through a small lake, 7 chains wide, requiring 9 feet depth of excavation in its bed; thence $\frac{66}{100}$ths mile to 17 feet depth of water in the harbor at low tide, the average cutting is about 16 feet. This cut is to connect with the natural harbor on its southerly side, and at the central portion of its deepest water; its sides are to be protected with a vertical docking, and that portion between the lock and the natural harbor is to be surmounted with a wall of hydraulic masonry. The artificial harbor will contain an area of 13 $\frac{40}{100}$ths acres; this added to 250, the number of acres of 18 feet depth of water in the natural harbor, makes an aggregate of 263 $\frac{4}{10}$ths acres.

There are facilities for obtaining additional harbor room, by excavations in the bed of the lake, extending southwesterly in rear of the town, which has an average of about 6 feet depth of water; by excavations at points the most favorable in the natural harbor, also by a cut, varying from 1 to 7 feet in depth, and about 1 $\frac{25}{100}$ths mile in length, through a bar above the entrance of the river, by which a communication would be opened to an area of over 275 acres with 17 feet depth of water. The area here alluded to is a stagnant pool, bounded by very low grounds on its westerly side; the entrance to it would require ptotection.

For a view of the plan of this harbor, see accompanying sketch.

MATERIALS NECESSARY IN THE CONSTRUCTION OF THE CANAL.

Timber.

The timber of the native or original forests of Nicaragua, as compared with that of the original forests of this country, is of inferior size. Trees of suitable form and height to furnish the ordinary timber required for the mechanical structures of the canal, and for general purposes of sawing, are also less in number on the same extent of surface; the difference is supposed to be considerable.

Between the summit level and the Pacific, the line traverses a section of country probably as heavily timbered as any other of equal extent in the State. The section of country upon either side of the San Juan river, extending from the Toro Rapids to a few

miles below the divergence of the Colorado, a distance of over 65 miles, has also, with very inconsiderable exceptions, its original forest, and, for that country, is heavily timbered. All of the timber found in that State is wholly unlike that of the productions of the higher latitudes.

Mr. H. Woniger, an intelligent gentleman, formerly of Pennsylvania, and for the last ten or twelve years a resident of Nicaragua, kindly presented several specimens of the most useful timber of the State, accompanied with remarks, from which the following are extracts:

"*No.* 1, *Cedar.*

"This is the best for building purposes; it is strong, though not heavy, and is very durable above ground." There is one place, Salinas, where it is found in large quantities, and where it has not been cut away, in consequence of the difficulty in passing a high ridge, which occurs between that and the inhabited part of Nicaragua. This supply of Cedar is found on a flat country, and will not exceed six miles from the harbor of Brito. It grows to a very elevated height and will produce timber from 36 to 40 feet long, and 12 to 18 inches square.

"*No.* 2, *Roble.*

"This, like the former, is a very firm wood; it is a very elevated tree; and the one from which the sample was taken produced a stick of timber 45 feet long and 18 inches square."

"*No.* 3, *Nispero.*

"This is a very common forest tree, and grows to a great height; it will produce timber 45 to 50 feet long, by 18 inches square. It is very durable above ground, but is not much used, on account of its weight."

"*No.* 4, *Laurel.*

"A very firm and durable wood above ground. Timber 30 feet or more in length, and proportionably large, may be obtained from it."

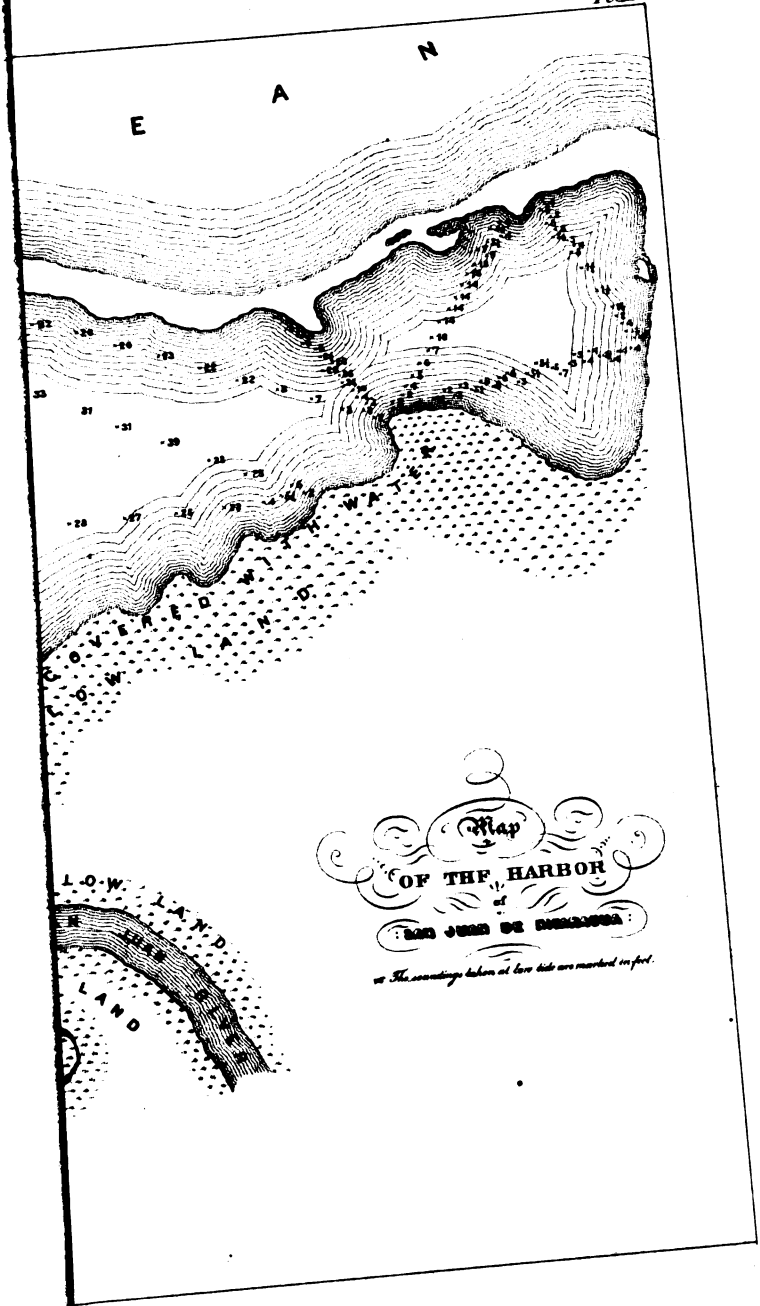
"*No.* 5, *Madeira Negra.*

"This is an exceedingly durable wood; it is much used for posts set in the ground, which will last from forty to fifty years. Timber from this tree can be procured 25 to 30 feet long, about 11 inches square; of shorter sticks an almost unlimited supply may be obtained."

"*No.* 6, *Niambaro, or Rosewood.*

"This, like the former, is a very strong and durable wood, even under ground, and will produce timber of greater length than the Madeira Negra. Considerable quantities may be obtained in the flats near Brito."

Pl. IV.


E A N
COVERED WITH WATER
LOW LAND
LOW LAND
LAND
Map
OF THE HARBOR
of
The soundings taken at low tide are marked in feet.

"*No.* 7, *Tiguilote.*

"This, though a light wood, will last many years under ground. It is occasionally found large enough to furnish timber from 30 to 35 feet long. The principal localities are on the borders of the lake."

"*No.* 8, *The Guachipilin*

"Is a very heavy, hard and tough timber, grows large, and is lasting in the ground."

"*No.* 9, *The Caobo, or Mahogany.*

"This is an inferior wood for furniture, but excellent for building purposes, being very similar to cedro, and a little heavier; it will produce timber 30 feet long and 12 inches square."

"*No.* 10, *The Palo de Arco*

"Is a firm and durable wood above and below ground; it is found large enough to produce heavy posts from 15 to 20 feet long."

"*No.* 11, *The Guanadillo.*

"I add this, as it is thought the handsomest timber for furniture."

"*No.* 12, *The Fenisaro.*

"A very large tree, and is good for all timber purposes."

The comparative strength and specific gravity of the above specimens, including a specimen of close straight grained well seasoned white oak, and white pine of this country, were tested in the following manner:

The specimens were each reduced to precisely one fourth of an inch square and 12 inches in length, and their strength tested by placing them in a horizontal position, on supports precisely ten inches apart, and carefully noting the weight suspended at the centre with which each piece was broken; and their comparative specific gravities was ascertained by allowing them to float in a vertical position in a vessel of water, and noting the length immersed.

The results of the experiments, although in some degree defective for the want of a larger number, are nevertheless considered sufficient to furnish a general practical view of the strength of the sevral kinds of timber as compared with oak, the timber of which lock gates and other parts of the wood work of the mechanical structures of the canals of this country, requiring strength and durability, are principally constructed. The Nispero is well known to be among the most common timber of that country, and, as appears from the experiments, is 29 per cent. stronger than white oak; it may be obtained of sufficient size, and if durable, it is believed may with safety be relied on as a good substitute for all of the purposes of the canal to which oak is usually applied, and that there are other

kinds of timber from which plank and other lumber may be sawed, among which may be named "Roble," "Cedar," "Tiguilote," "Fenisaro," and others, probably sufficient in the aggregate to produce all the lumber required for use in the construction of the canal.

The following are the results:

No. of Specimens.	Name of Wood.	Breaking weight in pounds.	Strength compared with Oak.	Specific gravities compared with Oak.	Deflection in inches.	REMARKS.
1	Cedar..........	14·06	0·52	0·87	1·	Broke sudden, with short fibres.
2	Roble..................	8·19	0·30	0·82	......	Do do do
3	Nispero.......	35·00	1·29	1·64	0·95	Fibres coarse; fracture 6 inches long; sank slowly; specific gravity estimated.
4	Laurel................	18·13	0·67	1·11	1·25	Fibres short.
5	Madeira Negra...	29·07	1·07	1·56	1·50	Fibres coarse and long.
6	Rosewood............	31·94	1·18	1·58	1·75	Broke sudden; fibres short.
7	Tiguilote.............	10·13	0·37	0·66	1·60	Do do do
8	Guachipilin	19·13	0·70	1·32	1·70	Do do do
9	Mahogany.	17·13	0·63	1·13	1.	Do do do
10	Palo de Arco.......	33·06	1·22	1·48	1·25	Fracture long, with coarse fibres.
11	Guanadillo..........	......	Omit	ted·	......	Furniture timber.
12	Fenisaro.............	12·13	0·44	0·92	1·08	Broke sudden; fibres short.
13	White Oak..........	27·06	1·00	1·00	1·80	Fine brushy fibres at fracture ¾ inches long.
14	White Pine..........	10·81	0·39	0·62	1·08	

Stone.

Detached irregular angled stone was found on the surface of nearly all of the hills approaching the San Juan river, and in some of them rock in place was discovered, from which there probably may be obtained stone of a suitable quality for the construction of the locks and dams. The rock consists principally of trap, greywacke and shale, which, although at some of the localities is of so friable a texture as to be unfit for use, at others there probably exists a good material for the purposes of the canal. Among these localities may be named that at the Balas Rapids, on the bank of

the river, about one mile below Machuca, and several others between the San Carlos river and the location of dam No. 7; below the latter point no stone suitable for the mechanical structures were discovered.

On the west side of the lake, limestone was found in the table lands at several localities, one about two and half and another about nine miles distant from the lake, and both within three miles of the line across the summit. Kilns are in operation at these quarries, producing lime; it was also found in the dividing ridge on the transit road, presenting a vertical face of some twenty feet in height in the bed of the Chirarar, a small stream on the western slope of the dividing ridge. Old lime works were noticed near the base of the easterly slope of the same range of hills, near the Rio Grande, some four or five miles southerly from the western termination of the summit level. A short distance west of these works, in a much more elevated position on a branch of the Rio Grande, was also noticed a mural escarpment, or cascade, of some 80 feet in height. The character of this rock was not ascertained.

Near the westerly end of the summit level, a low short spur from the hill containing limestone is crossed by the line; although at the surface this material appears to be of too thin strata to be useful in the work, thicker courses at greater depths may be found.

The hills on the southerly side of the Rio Grande, between this point and the Pacific, have more or less stone on their surfaces, and excepting the sand beach fronting the valley of this stream, the coast for many miles in either direction from Brito harbor has an elevated irregular rocky face. No quarries having been opened in the immediate vicinity of the line, the distance it may be necessary to haul a large portion of the stone for the locks, and the rectangular wall in the jettie, is rendered less certain. In the estimate it is assumed that the stone for the moles of the jettie may be obtained within three miles, and that for the rectangular wall and the masonry of the locks, the average distance of haul may be as great as ten miles.

Several specimens of stone in the vicinity of the line were obtained, and with reference to more reliable information as to their associations, they were forwarded to Professor James Hall, of Albany, an eminent geologist, for examination. In his communication relating to them, he remarks: "The character of many of the specimens indicates that you have within your reach durable materials for any structures that may be required in the undertaking in which you are engaged. I would direct your attention to masses like Nos. 4 and 5, as being in their character well suited to your purposes if found in masses of sufficient thickness, also to No. 7 as before mentioned. The limestones are of a character to be durable if you can find the beds of sufficient thickness." "No. 9 is almost entirely pure carbonate of lime."

Nos. 4 and 5 are a species of trap which prevails extensively on the west side of the lake, and to a considerable extent in the valley of San Juan. No. 4 was taken from the island of Ometepe, more with reference to ascertaining the general characteristics of the rock of the country than to immediate use. No. 5 was obtained from the Granada quarries, where a similar rock underlies a large extent of country, and from which the base of columns in buildings, curb stone and flagging for side walks, &c., in Granda, are obtained. These stone are easily wrought, and it is believed that blocks of any desirable dimensions might he readily obtained. This quarry would only be resorted to in case the stone in the valley of the river should prove unsuitable, a circumstance considered very improbable. The cut on the easterly portion of the summit level will probably be in a similar rock, and it is believed to exist in the hills between that level and Brito. No. 9 is a specimen of the rock forming the cascade on the Chirarar before alluded to, from which stone in any quantity and dimensions that may be required can be quarried. If on opening a quarry on either side of the valley of the Rio Grande the stone should prove defective, and suitable stone could not be found at any more convenient locality, stone from the Chirarar might be hauled on the transit road, about four miles to the harbor of San Juan del Sur, and boated thence eleven miles to Brito; although the necessity of obtaining suitable stone under disadvantages so great is regarded a contingency quite remote; it is not deemed prudent to adopt prices below an equivalent to those required for obtaining at this quarry the larger blocks required in the work on the westerly portions of the canal, and from the limestone quarry before alluded to, about four and a half miles south of the summit, for the residue of the work west of the summit.

From information derived from citizens of San Juan del Norte, it appears probable that stone might be obtained on the Atlantic coast, at Monkey Point, about forty-two miles northerly from San Juan, at Frenchman's Key, fifteen miles south of Blewfield, and at Little Corn Island, some few miles off the coast from Blewfield. There being no harbor at the two former places, they could only be approached by vessels some four or five months in each year; at the latter there is said to be a good harbor, where stone of an excellent quality might be obtained. Should this prove correct, of which there appears to be much probability, stone for the work on the lower end of the line might be more conveniently obtained from this point than from any other.

Water Lime.

No stone from which water lime can be manufactured, of a quality suitable for the more exposed parts of the masonry required on the canal, was discovered; although this material may exist in the country, the opening of quarries has not, so far as is known, been

sufficiently extensive to disclose it. Specimens of the stone from which lime is manufactured, and quite extensively used in the construction of vats for the manufacture of indigo, were procured, two of which have been subjected to analysis by Professor Hall, and the following shows their composition, together with that of the stone from which water lime is manufactured in the counties of Ulster and Madison, in this State, and used in the construction of the New York Waterworks, the enlargement of the Erie Canal, and in other States of the Union; also, an analysis of the sheppy stone, understood to produce a cement among the best used in England.

Constituents in 100 parts.	Nicaragua Stone, No. 1.	Nicaragua Stone, No.	Ulster County Stone.	Madison County Stone.	Best Sheppy Stone.
Carbonic acid, }	36·89	38·73	......	......	20·00
} Carbonate of lime	......	......	59·70	66·00	......
Lime }	47·51	49·80	......	......	35·00
Silica	7·13	3·13	15·37	8·95	17·75
Alumina and Iron	6·81	3·62	11·38	6·65	12·75
Magnesia	1·12	4·21	12·35	16·70	0·50
Potassa	trace	trace	......	......	......
Soda	"	"	......	......	......
Chlorine	"	"	......	.....	......
Sulphuric acid	......	0·09	......	......	......
Water	......	......	1·20	1·70	3·00
Manganese	.. ...	......	......	......	1·00
	99·46	99·58	100·00	100·00	99·C0

From a comparison of the foregoing analysis, it appears that the Nicaragua stone contains a larger proportion of lime, and less silica and alumina, than either of the others; the larger proportion of magnesia in the Ulster and Madison county stone is rather an evidence of less proportion of lime in the carbonates than of utility to the cement made from these stones; the magnesia being in this respect, to a great extent, a neutral substance in the composition. A larger proportion of alumina and silica in the Nicaragua lime would therefore probably improve its hydraulic properties. On this subject, Professor Hall, in his communication, remarks "that by burning with this lime a clay, in proportions that could be determined by a few trials on a small scale, you may produce a cement; the clay No. 14, I would recommend for this purpose."

The specimen of clay alluded to was taken from the bottom of the lake, within the limits of the proposed cut, about one and a half miles from the outlet; it is of exceeding fineness, and would probably be used, as above recommended, if none other equally good, and in a more convenient locality, could be found.

The Nicaragua lime is used in that country in all wet and dry masonry, such as the stoning of wells, which in many instances is done with hydraulie masonry from the bottom, and forms the curbing at the top, for plastering both the inner and outer sides of the adobe walls of dwellings, &c.; it is quite extensively used in the construction of indigo works, which consist of some two or three vats, each about twenty feet square, and some six or eight feet in depth; these adjoin each other, and have different elevations, they are located by the side of permanent streams, the waters of which are raised by dams of hydraulic stone masonry, usually some ten to fifteen feet in height, from the top of which the water, in a square trench cut in earth and lined with masonry, is conveyed to the upper vat, from which it is passed through the series. Among these works were noticed some, said to have been standing over eighty years, and notwithstanding their exposure to the action of severe currents, and usage, are now in a very perfect condition; although the mortar in these works is more friable than that made with the best cements of this country, it has sufficient strength to render it evident, that a cement of equal hydraulic properties will be suitable, with a trifling increase to the thickness of walls, for a large proportion of the masonry in nearly all of the structures required on the canal. In view, however, of the uncertainty of finding in that country a better material for cement, and of sufficiently improving that known to exist there, the expense of a good article from this country for the more exposed parts of the masonry is provided for in the estimate.

(To be continued.)

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. BY J. RICHARDS, M. E.

(Continued from page 89.)

Band-Saws.

CONCERNING the origin of the band saw there is no published record that can be relied upon. So far as fixing it as a special invention, it is highly probable that its origin could not be traced, as it has without doubt been invented and suggested repeatedly in all civilized countries where the growth of the mechanic arts led to the want of such machines.

The first general and successful application of band saws to manufacturing purposes is due to Perrin, of Paris, France, who has, during the last twenty years, brought band sawing machines, or rather band-saw blades, to a high degree of perfection. Previous

to his efforts, and during his earlier manufacture of blades and machines, the popular notion prevailed that no blade could be made to endure the bending, tension and high speed. The importance and practical performance of the machines, aside from that consideration, was generally conceded by all. Even now a large proportion of our mechanics and manufacturers in the United States are skeptical as to the endurance of band-saw blades.

The English manufacturers of wood cutting machines soon saw in the band-saw a machine that avoided the many serious objections that applied to gig or reciprocating saws for scroll cutting—a machine with rotary movement, that could be made in a durable form, not liable to derangement, and adapted to their distant markets, where these considerations were paramount; capable alike, under a single modification, of cutting in heavy or light work, hard or soft wood, and with blades of any width. The leading mauufacturers have adopted it in all cases where it can be applied, and have been continually modifying and improving the machines during ten years past, until the band saw, from being an experimental "curiosity," has become a standard machine, ranking in importance with the circular and reciprocating saw.

In the United States it may be safely assumed that no machine for wood cutting has ever, in the history of our country, been so successfully and rapidly introduced. During five years past the band-saw has been introduced into nearly all of our best wood shops for scroll cutting, and now bids fair to supplant other sawing machines for straight lines. It is used for cutting leather, bone, cloth, and even slate stones, and may become the general means of dividing all kinds of material, including hard metal.

Herr Krupp has recently introduced a machine of strong proportions for metal cutting in his works at Essen, Prussia, an illustration of which appeared in a late number of *Engineering*.

The English manufacturers, with their knowledge of general construction and their engineering talent, have produced some superior designs for band-sawing machinery, characterized by their usual proportions for obtaining strength and efficient performance. In some of their details, their machines are fairly open to criticism, in the way of guiding the blades, for instance, and in the flanges for keeping them on the wheels; but in the arrangement and distribution of metal in the framing there is but little left to be done.

The saw on one of these machines is like the string on a bow. An examination of the framing discloses at a glance whether the design was made with a knowledge of this condition. In fact, in all machines there is no surer key to the intelligence and skill of the designer than to follow the strains, and see if they are met and neutralized in the framing. A knowledge of the existence of strain shows a familiarity with functions and conditions of operation, while the disposition of material to resist it, measures the constructive talent and engineering knowledge that has been brought to bear in producing the design.

The band-saw considered with reference to the general principles of its operation is one of the most simple of machines, consisting merely of an endless saw, running like a band over two pullies, with guides to sustain it against the thrust of the work and to keep it in line, there being really but two vital questions involved in determining for or against its general application. These are *the endurance of the blades and means of resisting the back thrust.*

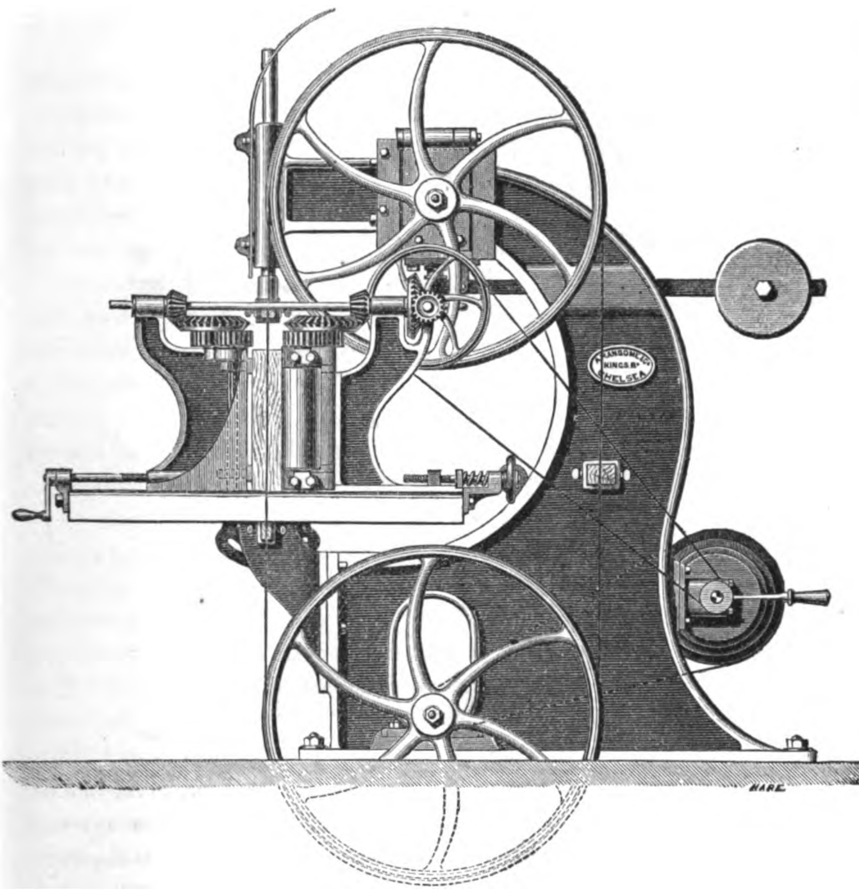
The speed of its work, and the consequent reduction in cost, it is unnecessary to consider, for, as assumed in a former article, the speed and cost of sawing is inversely as the velocity of teeth, other conditions being equal, the saw dust supplying the fuel for power. The band-saw can be driven at a higher speed than any other known machine for sawing, and we have left to consider only the two problems mentioned, in order to determine its future importance.

The first, as to the *endurance of blades*, is rapidly reaching a solution. Band-saw blades of good quality, when operated on properly constructed machines, give a greater amount of wear at a given cost than even circular saws. This statement could not have been ventured two years since, and must now be construed as applying to *good blades.* Perrin's blades, when treated with care, can be relied upon to last until worn out, without breaking, when upon machines that have strength and proper adjustments. The wider blades, for re-sawing, or for straight lines, can be bought under a guarantee of their withstanding all the ordinary conditions of use until their cross-section is reduced too much to withstand the necessary tension, and we are yet in the infancy of their manufacture. In the light of these facts, we can, with a degree of certainty look for a time, not distant, when the wear and endurance of the "endless blade" will outrank all others. Its thin section and great length gives an important advantage in the cost of manufacture, and there is no danger

to be apprehended from buckling, or injury to the plate, as in circular saws.

The second question, of *the means of resisting the back thrust,* is one that does not admit of so easy a solution. It is hard to conceive of a means of preventing abrasion with a thin sheet of hardened steel moving at a rate of from 3000 to 5000 feet per minute

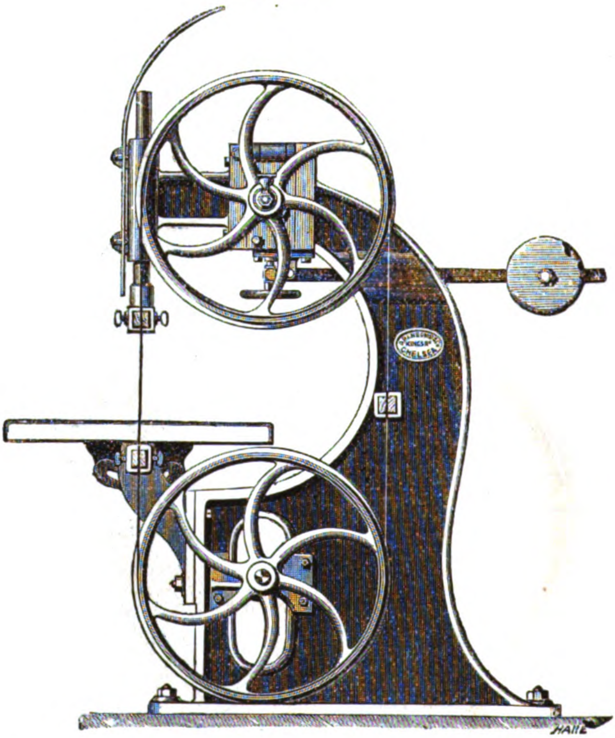
Fig. 1.



against stationary supports. In machines for scroll cutting that are operated with hand feed, it is not so difficult to meet this problem, but with a positive automatic feed the conditions are very different. "Rolling contact" would, of course, be the natural suggestion, but could only present a "*hair line*" bearing for the blade,

and would soon "upset" or elongate the back of it. Besides, rollers of any kind could only be applied at a distance equal to their radius above the suff, which, for narrow blades, would expose them to deflection across their deep section and break them. The flanges that are generally found on the wheels of these machines can contribute nothing in the way of sustaining the back of the blade, because of their distance from the work. The long distance traveled

Fig. 2.



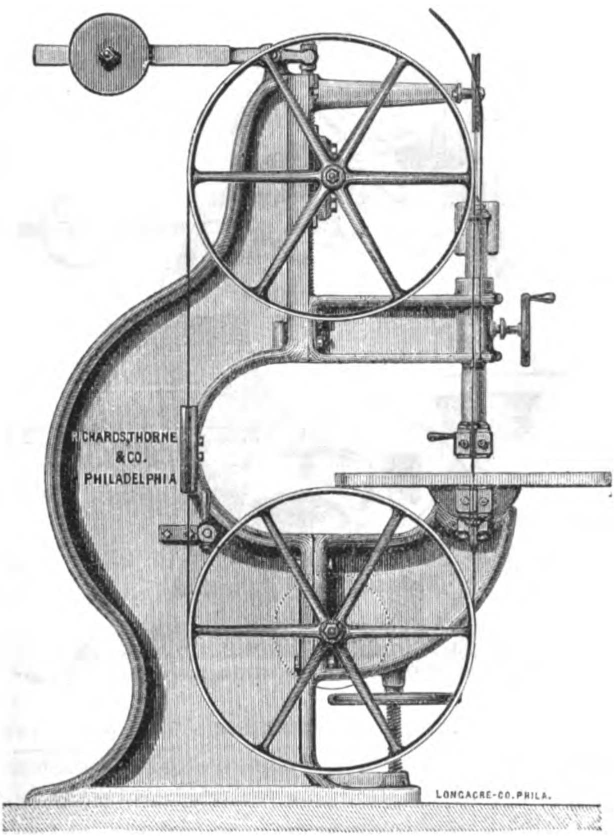
by the blade after passing through the wood, however, gives one of the important conditions necessary to overcome abrasion against the guides. No considerable abrasion, or at least no rapid, or destructive abrasion, can take place between metal surfaces at a low temperature, which this long travel of the blade maintains, at least in the top guides, and it is perhaps safe to say that the best means of resisting this back thrust on saw blades of this kind is by the use of hardened steel surfaces, made as long as possible, to obtain a good bearing, and arranged to be renewed with great convenience,

without loss of time or expense. The finest cast-steel, when hardened at a high heat in a bath of salt and ice, possesses an endurance that is almost incredible, as a back support for band-saw blades.

Richards, Kelley & Co., of Philadelphia, in their band sawing machines that have automatic feed, apply lubricating devices in connection with hardened steel supports.

Perrin, of Paris, uses a block of hard wood, which, with the back of the saws well finished and rounded off, answers a good purpose under moderate strain.

Fig. 3.



Allen Ransome & Co., of London, England, employ on their machines for scroll cutting, rolling guides of hardened steel, with lateral guides of the same material.

The illustration (Fig. 1) shows a side elevation of a band-saw machine for re-sawing, with automatic roller feed, as constructed by Messrs. Allen Ransom & Co., of London, England.

This machine can be classed as a "light" re-sawing machine for lumber of less than twenty inches deep. The weight is about two tons, including the feeding mechanism, which can be readily detached, leaving the machine as a scroll cutting or slitting saw. The feed is arranged at a maximum of thirty lineal feet per minute.

Fig. 4.

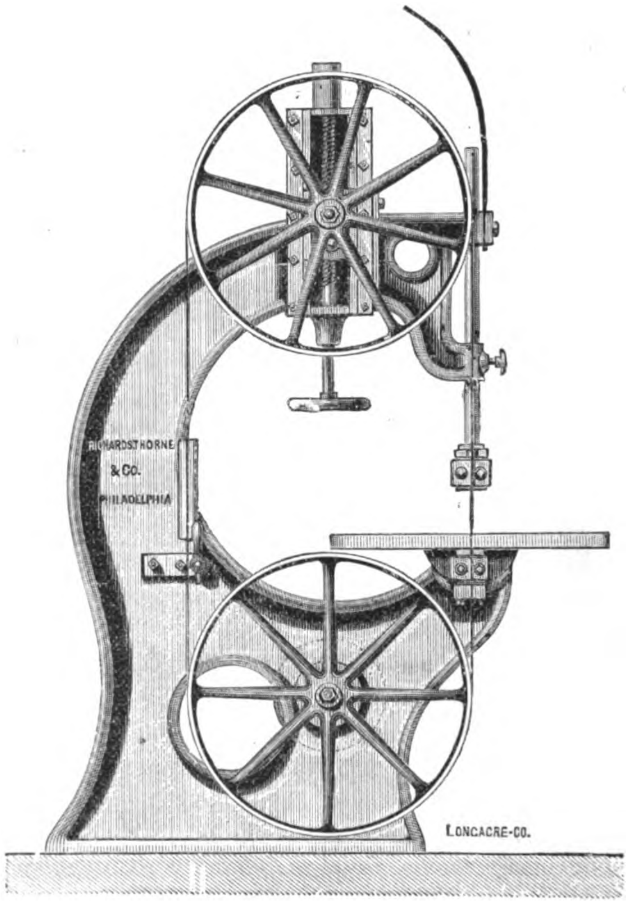


Fig. 2 is a scroll band-sawing machine of twenty-two hundred weight, by the same manufacturers, with strong, substantial framing, and embodies many recent improvements which the enterprise of this firm leads them to adopt in all of their machines, as soon as approved by experiment.

Fig. 3 is a true elevation of a No. 4 machine, from the designs of Richards, Kelly & Co., of Philadelphia.

The lower wheel, with the table, is carried upon a movable bracket that admits of an adjustment to suit the thickness of the lumber or to regulate the tension of the driving belt. The saws are strained by the weighted lever seen on top. The guide stem is counter-balanced, to render the adjustment easy; and the saw tension is regulated by the wheel seen on the right of the engraving. The weight of this machine is 3,750 pounds; average speed of saw 3,000 feet per minute; capacity of depth 18 inches.

Fig. 4 illustrates a No. 3 machine manufactured by the same firm. The weight is two thousand six hundred pounds. The frame, including the table support, is cast in one piece, a form of construction that insures great rigidity, and at the same time preserves the beauty of design. The contour of the frame consists throughout of true curves, struck from radial points, and is the subject of a design patent granted to the manufacturers. The adjustments are simple and the wearing parts arranged with reference to durability and exact movement.

These several illustrations are all true elevations to a scale of $\frac{1}{2}''$ to 1 foot, and, of course, represent the machines correctly in all respects. These illustrations have been selected with reference to the purpose of these articles; which is, to give samples of modern engineering in this department of the arts; and notwithstanding the fact that the band-saw is one of the latest machines developed, it must be conceded that but few if any wood cutting machines can be considered as presenting equal claims to perfect construction, both as regards symmetry and adaptation.

This article will be closed with some general suggestions as to the construction and operation of band sawing machines, gathered from the experience of the writer, who has been interested in their manufacture, under several modifications, in the United States and England.

The frames should be strong enough in their cross-section to resist the strain of the saw, which will otherwise throw the guides and other parts out of line, or allow them to vibrate. The wheels should have no flanges, and the top one should be so arranged that the plane of rotation can be instantly changed to regulate the path of the saw upon its periphery, and by this means regulate the amount of strain against the guides.

The speed of the saw may be from two to three thousand feet per minute; it is, however, a matter to be determined by the character

and speed of the cutting to be done. If the lines cannot be followed rapidly, it is useless to drive the saw faster than it can be fed.

Provision should be made for the expansion and contraction of the blade by elastic springs or weighted levers connected with the straining devices. The saws should be kept sharp, and should never be allowed to get sufficiently dull to require forced feeding, which of course falls on the back supports of the guides.

In joining the blades, brazing is the popular plan in England, and perhaps the best one, but not so convenient as silver solder, which makes a reliable joint, and one which can be made without a blow-pipe. The blade should be scarfed and then washed clean with acid, a sheet of the prepared solder placed in the lap, and the whole lapped with fine wire. By clasping the joint, when thus prepared, with a pair of tongs heated to a full red heat, the solder will melt and the surplus run off, leaving a neat, strong joint. To hold the blade during the operation, an iron clamp is necessary, which should be planed true, to insure that the saw is straight after joining. Many omit the wire lapping as unnecessary, but, as a rule, too much of the solder runs off if the tongs have to remain until the temperature is low enough to remove them, without risk of the joint opening.

(To be Continued)

EXPERIMENTS UPON THE SWAIN WHEEL NO. 3.

Made at Lowell, Mass., by HIRAM F. MILLS, C. E.

AFTER the experiments with the Swain Wheel, made in June, 1869, and recorded in the *Journal of the Franklin Institute*, Vol. LIX., No. 3, the patterns of the 42-inch wheel were changed by removing the upper two inches of the band *b b*, (Plate II. of the above report,) which surrounds the lower part of the buckets, thus increasing the depth of opening through which the water enters the wheel from 5·35 inches to 7·4 inches. The gate, guides and guide chamber were correspondingly increased in height, but buckets of the same form, stamped by the same dies were used, and the guides were put at the same angle, and the whole apparatus was evidently as near as could be reproduced the same as before, excepting the necessary changes in the vertical direction involved in the increased motion of the gate.

The crown of the wheel was thus raised four inches higher from

the floor of the pit, but the crest of the weir was raised about the same amount, hence their relative position was as before.

The wheel was of ordinary finish, the castings were well cleaned and the surfaces coated with red paint.

The following dimensions were measured after the wheel was removed from the pit:—

Mean vertical distance from the under side of the crown to the lower edge of the buckets	1·144 feet.
Mean vertical distance from the under side of crown to bottom of lower band	1·156 feet.
Mean vertical distance from the under side of crown to top of lower band	0·629 feet.
Mean shortest distance of the inner edge of one bucket from the adjacent bucket at 1 inch below the crown	0·065 feet.
Do. do. at 5 inches below the crown	0·079 "
Do. do. at 10½ inches below the crown	0·110 "
Do. do. at 1 inch from outside at the bottom	0·135 "
Mean shortest distance from the inner edge of one guide to the adjacent guide	0·219 feet.
Mean shortest distance from the outer edge of one guide to the adjacent guide	0·334 feet.
Mean area of outlets of wheel	18·87 sq. inches.
Total area of outlets of wheel	3·276 sq. feet.

The apparatus for weighing the power of this wheel was essentially the same as that used by Mr. Francis in experiments upon the Tremont Turbine, described in detail in his "Lowell Hydraulic Experiments." The scale pan, hydraulic regulator and bell crank, with their bearings, were the same as were used in those experiments; the brake and friction pulley were of similar form but somewhat reduced in size, the latter having a diameter of 42·03 inches, and a face 10·5 inches wide.

The large frictional surface allowed the use of water as a lubricator and substituting a worm gear and hand wheel in place of the levers by which the amount of friction was regulated, a very steady motion was maintained throughout the experiments.

The weight of the friction pulley and brake which was supported by the step of the wheel was 2,612 pounds. This weight being much more than would be imposed upon the step when in use in a factory, a portion of it was counterbalanced by ropes attached to the brake, and passing over pulleys about one foot in diameter and eight feet above the brake, so fixed that the ropes would draw vertically when the pointer on the bell-crank was at zero. Four of these ropes, attached to the brake symmetrically with respect to the

shaft, supported at the other end a little more than 400 pounds apiece. The fifth rope, attached near the point of attachment of the link connecting with the bell crank, supported at the other end, 152 pounds, making a total counterbalancing weight of 1,782 pounds, and leaving upon the shaft a weight of 830 pounds corresponding to that of an ordinary crown gear for this wheel.

The measuring weir was bordered by plates of cast iron having sharp and square up-stream edges. The length of the crest was 9·996 feet, and its height above the floor of canal approaching 3·51 feet.

The apparatus for measuring the depth of water upon the weir, for the suppression of whirls in the water approaching the weir, and that for measuring the fall acting upon the wheel were the same described in the report upon the first Swain Wheel previously cited.

The method of conducting the experiments was also the same as there described. The data and results of these experiments are arranged in the following table, in which the mode of computation previously described was followed.

The distance from centre of shaft to the point of application of the link, to the arm of the brake, measured at right angles to the direction of the draft was 8·164 feet. The length of the vertical arm of the bell-crank was 4·4955, and of the horizontal arm 5·0027, making the effective length of the lever 9·085 feet, and the circumference corresponding 57·083 feet.

From this table it will be seen that the mean maximum efficiency of the wheel is as follows, viz:—

With full gate..	$81\frac{7}{10}$	per cent.	of the power	of the	water.
With seven-eighths gate..............................	$81\frac{7}{10}$	"	"	"	"
With three-quarters gate..............................	$80\frac{9}{10}$	"	"	"	"
With one-half gate......................................	$76\frac{7}{10}$	"	"	"	"
With one-quarter gate..................................	$61\frac{5}{10}$	"	"	"	"

Or, classifying the results with reference to the quantity of water the wheel can discharge; they may be stated thus:—With full quantity the efficiency of the wheel was $81\frac{7}{10}$ per cent. of the power of the water; with 90 per cent. of the full quantity of water, 81 per cent. of the power of the water used; with 80 per cent. of water, $79\frac{5}{10}$ per cent.; with 70 per cent of water $76\frac{7}{10}$ per cent.; with 60 per cent. of water, $71\frac{7}{10}$ per cent.; and with 50 per cent. of water, 65 per cent.

Essex Co.'s Office, Lawrence, July, 1870.

ELL, MASS., MARCH 29, 1870.

1		12	13	14	15	16	17	18	19
No. of the Experiment.	Date 1870	Height of the Water in the Wheel-pit in feet.	Total fall acting on the Wheel in feet.	Depth of water on the Weir in feet.	Quantity of water which passed the Weir in cubic feet per second.	Power of the water in lbs. raised one foot per second.	Ratio of the useful effect to the power expended.	Velocity due to the fall acting on the Wheel in feet per second.	Ratio of the velocity of the exterior circumference of the Wheel to the velocity due to fall on Wheel.
1	Marc	1·701	13·655	1·3871	53.378	45466·3	·809	29·636	·798
2	"	1·707	13·819	1·3947	53·800	46346·2	·810	29·814	·762
3	"	1·696	13·337	1·3831	53·148	44217·1	·814	29·290	·753
4	"	1·695	13·377	1·3849	53·237	44422·0	·816	29·333	·745
5	"	1·697	13·304	1·3862	53·320	44250·4	·819	29·254	·735
6	"	1·695	13·386	1·3874	53·395	44584·4	·814	29·333	·723
7	"	1·691	13·163	1·3845	53·220	43698 7	·817	29·098	·706
8	"	1·682	13·094	1·3802	52·995	43285·8	·787	29·021	·647
9	"	1·683	13·074	1·3891	53·493	43625·2	·790	28·999	·628
10	"	1·671	12·826	1 3780	52·848	42280·3	·754	28·723	·566
11	"	1·685	12·948	1·3835	53·175	42949 5	·713	28·859	·514
12	"	1·703	12·938	1·3914	53 620	43276·2	·683	28·848	·473
13	"	1·700	12·900	1·3907	53·575	43110·9	·628	28·806	·434
14	"	1·697	12·930	1·3851	53·270	42965·8	·539	28·839	·348
15	"	1·654	13·960	1·3381	50·590	44055·9	·811	29·967	·819
16	"	1·659	13·931	1·3424	50·825	44167·9	·803	29·935	·801
17	"	1·661	13·907	1·3440	50·905	44158·7	·806	29·908	·791
18	"	1·668	13·884	1·3461	51·040	44203 5	·809	29·884	·782
19	"	1·664	13·868	1·3491	51·218	44307·2	·807	29·867	·770
20	"	1·665	13·864	1·3500	51·250	44313·3	·815	29·862	·765
21	"	1·665	13 851	1·3514	51·340	44358·3	·816	29·849	·754
22	"	1·668	13·854	1·3528	51·413	44432·2	·818	29·852	·722
23	"	1·663	13·861	1·3549	51·540	44563·3	·782	29·859	·634
24	"	1·590	14·023	1·2680	46·710	40859·1	·778	30·033	·816
25	"	1·604	14·003	1·2798	47·350	41360·7	·804	30·013	·777
26	"	1·607	14·010	1·2813	47·440	41457·8	·808	30·020	·769
27	"	1·610	14·012	1·2838	47·576	41582·5	·811	30·022	·760
28	"	1·611	14·010	1·2876	47·790	41763·9	·808	30·019	·747
29	"	1·601	14·019	1·2904	47·940	41922·2	·809	30·029	·726
30	"	1·606	13·989	1·2917	48·010	41895·3	·802	29·997	·686
31	"	1·599	13·988	1·2916	48·070	41945·0	·776	29·996	·625
32	"	1·594	13·985	1·2908	47·962	41839·1	·742	29·992	·563
33	"	1·422	14·432	1·0827	36·920	33236·3	·691	30·468	·881
34	"	1·452	14·356	1·1064	38·148	34162·0	·748	30·388	·810
35	"	1·457	14·337	1 1148	38·570	34494·2	·761	30·368	·775
36	"	1·458	14·334	1·1211	38·900	34780·8	·759	30·364	·745
37	"	1·460	14·330	1·1245	39·070	34923·1	·764	30·360	·736
38	"	1·462	14·321	1·1269	39·195	35012·8	·770	30·351	·723
39	"	1·463	14·313	1·1291	39·320	35106·1	·766	30·342	·697
40	"	1·151	14·694	0·8282	24·810	22740·7	·558	30·743	·791
41	"	1·165	14·714	0·8306	24·915	22867·3	·582	30·764	·758
42	"	1·172	14·739	0·8398	25·304	23264·6	·586	30·791	·723
43	"	1·174	14·740	0·8423	25·425	23377·4	·600	30·792	·702
44	"	1·185	14·732	0·8472	25·640	23562·3	·608	30·783	·665
45	"	1·189	14·734	0·8503	25·780	23694·2	·613	30·785	·627
46	"	1·196	14·733	0·8528	25·890	23794·5	·616	30·787	·592

CENTRALIZING MOTIVE POWER.

By J. Richards, M. E.

The most important element in human industry is the employment of the forces of nature to produce effects beyond the scope of manual effort. To convert the crude materials of nature into such forms as will give us shelter, food, clothing, comfort, and pleasure, is the business of human life. If the reader will glance around him, no difference where he may be, I doubt whether he will be able to find a single article, great or small, of human production, that does not in some degree owe its origin to the employment of physical force; and perhaps not one that is not, directly or indirectly, the product of steam power. It forms an interesting problem. The paper on which we write, the pen, even the modern pen stem, the paper on the walls, every nail, the clothes we wear, the buttons, even the gas that furnishes the light, can be traced back to the steam engine, or other motive power, that has been the main agent in its manipulation from the crude materials of nature.

It would be, further, a safe proposition to say that, next to human life itself, the great auxiliary of natural forces is to us the most important of earthly matters, so intimately are they connected with our civilization and welfare. A thing then so important as motive power should command our continual and earnest consideration. Its economy and safety should be the most important of all questions in science. Whatever contributes, even in a minor degree, to its improvement should be recognized as of the highest importance, and take precedence over other discoveries and inventions in the rank of its great importance.

The improvement of the steam engine has, no doubt, of all other mechanical subjects, received the greatest amount of scientific attention, but it has, without doubt, been too much confined to various modifications in its mechanical construction with a view to special adaptation, and such economy as could be attained by improvements in steam generators, furnaces and valve movements. The greater question of *aggregated* or *segregated* sources for power has not (at least in this country) received much attention. The question of localizing and distributing motive power bears directly upon the two greatest questions involved: the cost of power and its safety. As affecting these conditions, it is proposed then, in a brief way, to present some views as to what might be gained by centralizing mo-

tive power in manufacturing districts and distributing it to be used by the manufacturers as we do gas or water. The first thing, aside from physical practicability, to be considered, is a proper medium for transmitting accumulated force in a way to be graduated, measured, and carried to a distance. This medium nature has provided in our atmospheric air, freed from a single fault, in fact impregnating our systems and essential to life. It is without money and without price. Governed by the laws of gases, it has all the properties and fulfills all the conditions of steam for a common engine, except that of lubrication. It is not explosive, it is free from danger; after use there is no residue, it can be discharged in any room, conducing to its comfort in either winter or summer. It is so subtle that it can be carried to any distance through innumerable angles without diminishing materially the original force; and we must consider it strange to see the attempts recently made, in Germany and elsewhere, to transmit power by means of ropes and pullies, through long distances, instead of using compressed air for the purpose. In contrasting, or in considering different means of transmitting power to a distance, we find as the most important conditions: first, the loss by friction; second, durability; and third, first cost—we mean, of course, after demonstrating the practicability. Air has already been extensively employed for propelling machinery and in raising liquids, after being compressed by mechanical means. Its flow through pipes and the valves of engines and pumps has been demonstrated, and is, as we believe, determined by fixed formulæ. Machinery for compressing it, is well known either as the blowing engine or the hydraulic apparatus; so that perhaps the only things to be considered in suggesting a system of concentrating power at one point and distributing it to consumers, are the pipes for conducting it, and the saving that would be effected by such a system.

The difference in cost of generating 1000 horse-power by a single condensing engine, favorably located, when contrasted with the cost of producing the same power with forty non-condensing engines with 25 horse-power each, is, we will assume, as two to one, an assertion that is undoubtedly a safe one, when we consider the cost of attendance, room, wear, and fuel. Supposing that the cost of generating this power is in one case \$50 per horse-power per annum, and in the other \$100 per horse-power per annum, we have a saving representing the sum of \$50,000 per year in forty of our shops, supposing the amount of power used to average 25 H. P. each; or

should we assume that twenty steam engines of 50 H. P. each, would cost proportionately compared with the large one of 1000 H. P., we should have this saving represented in twenty manufacturing establishments using that amount of power.

This sum would lay conducting pipes through almost any of our manufacturing districts, to the extent of 1000 H. P., and we would in a single year pay for the piping, and in another year pay for the compressing machinery, while either would last for twenty years.

The saving in cost, although no doubt the question that would have most to do with the inauguration of a system of centralizing and distributing power, is but one out of many involved. With a "pneumatic main" laid through the streets of our manufacturing districts, and each manufacturer taking off his power through a meter, we would gain not only in economy and convenience over local steam power, but obviate nearly all that is objectionable in it. The danger from boiler explosions would be gone. The smoke from steam furnaces would be avoided, the heat and danger from fire would be avoided. The room would be saved, the water rate would be saved. The engine would not freeze in the winter. The cost would be as the amount of power used, which could be varied with the state of business; or a change in the capacity of the motive power could be made at a trifling cost.

May we not look for the next great innovation in motive power to consist in centralizing it and distributing it by means of pneumatic apparatus?

Gaseous and Liquid Phosgene.—A. Emmerling and B. Lengyel have found* that chloroform by oxidation with potassic bichromate and sulphuric acid yields phosgene: $2\,C\,H\,Cl_3 = 2\,C\,O\,Cl_2 + H_2o + Cl_2$. Along with the phosgene a certain quantity of carbonic acid arises, in consequence probably of a further decomposition. The gas is given off according to the proportions of the substances employed, sometimes rapidly, sometimes slowly. When generated at temperatures higher than the boiling point of water, it is mixed with oxygen. Phosgene, free from oxygen, can be obtained at a moderate rate of evolution from 50 pts. potassic chromate, 400 pts. concentrated sulphuric acid, and 20 pts. chloroform. The gas thus procured contains traces of chloroform vapor, and about $\frac{1}{15}$th its volume of carbonic anhydride. Phosgene easily condenses at 0° to a limpid, very mobile fluid, with an extremely suffocating vapor. It sinks like drops of oil in water, and is decomposed with formation of carbonic acid. It boils at 8·2°. A. R. L.

* Chem. Centrall Blatt. [3], 1, 69.

Mechanics, Physics, and Chemistry.

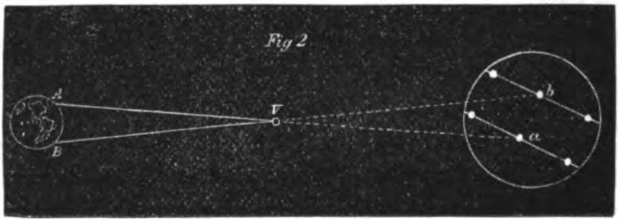
THE SUN.

(A course of five lectures before the Peabody Institute of Baltimore, January, 1870.)

BY B. A. GOULD.

(Continued from page 137.)

A TRANSIT of *Venus* takes place when this planet passes between the sun and the earth. Were she much nearer to us she might eclipse the sun on such occasions, as our own satellite does, although her true diameter is but about three-elevenths that of *Venus*. But she is too distant for that, and appears like a dark ball moving across the sun's disk from east to west. This interesting phenomenon occurs but twice in each alternate interval of one hundred and thirty and one hundred and thirteen years, the two occurrences in each of these periods being only eight years apart. At such times the disadvantages of observing *Venus* disappear, and are indeed replaced by very great advantages, so that no method of determining the solar parallax is comparable in precision with that afforded by a transit of Venus. Without entering into details, the general principle will be manifest from the diagram. The circumstances here differ from those of the observation of *Mars* in two important respects.



In the first place, *Venus* is seen not against the celestial sphere, but against the disk of the sun, so that the observer needs but to fix the position of the line across the sun, which she describes in her transit, and then the differences between the positions of these lines, as seen by different observers, afford a series of measures of the parallax of the planet. For, as the diagram shows, an observer at A would see the black spot move along the line *a a a*, while one

at B would see the transit along the line *b b b*. But a still more important advantage arises from the circumstance that the circular form of the sun renders even these measurements needless, inasmuch as the time which the transit occupies affords in itself a measure of the length of the line traversed, and, consequently, shows the distance at which it passes from the centre of the sun, the apparent diameter of the sun being known. Hence, a sharp determination of the times of the planet's entrance upon, and exit from, the face of the sun will give the distance of the line of transit from the centre; and such observations, if made at remote and favorably situated points on the earth's surface, afford the most accurate possible determination of the parallax of *Venus*, and thereby that of the sun. For, since we thus learn the true distance of *Venus*, and previously knew the ratio between this distance and the sun's our problem is solved.

The history of the observations of the transits of *Venus* in 1761 and 1769 is exceedingly interesting. Many of the occurrences were quite singular; indeed, the genuineness of some observations has been greatly discredited, and the correctness of others is still a subject of controversy. But I may not dwell upon a topic so entirely collateral. The observations were discussed and computed with great care, 60 years later, by the eminent astronomer, Encke, and for 40 years after his publication* of the results in 1824; the value which he deduced has been adopted by astronomers, being 8″·5776.

The years 1848—1852 witnessed an attempt at obtaining a more accurate value made by our countryman, Gilliss, who organized and carried out an expedition to South America for a new determination of the parallax of *Mars*, upon the same principle which had been employed by Cassini and Richer, a century and three-quarters earlier, but with methods and implements improved in proportion to the wonderful progress in astronomy during the interval. The original impulse for the expedition had been given by a plan of Prof. Gerling, in Marburg, for determining the parallax of Venus by a new method. This method did not command the universal confidence of astronomers, but when conjoined with the plan for observations of Mars, all agreed in approval of the expedition. Elaborate and excellent plans were prepared by Gilliss in advance, and the co-operation, not only of the two American observatories on nearly the same meridian, but also of observations in general

* Encke, *der Venusdurchgang von* 1769. Gotha, 1824.

throughout the northern hemisphere, was confidently relied on. He established himself at Santiago, the capital of Chili, and for nearly four years carried on a most thorough system of observations. Returning home, in 1852, he found his labors fruitless for the purpose for which they had been chiefly designed. Instead of copious series of observations in the northern hemisphere for combination with his own, he found so few, and these few of so inadequate a character, that the main object of his expedition was defeated. His own observations were unsurpassed in excellence; no labor was spared in the thorough computation of such others as were available, and in the attempt to render them serviceable; but the results proved discordant, and the only possible inferences untrustworthy. Fortunately, he had availed himself of opportunities for doing other important astronomical work, and had gathered more copious material than had ever before been obtained for a catalogue of a considerable portion of the southern heavens. But, alas, the preparation of these for publication was interrupted by his untimely death, and, to the dishonor of American astronomy, the observations are slumbering in the recesses of some government office, apparently forgotten, and there seems small likelihood of their being made available for science at present.

The observatory established in Chili yet remains, having been adopted by the Chilian government, and a competent astronomer placed in charge. And upon Gilliss' appointment, in 1861, to the charge of the Washington Observatory, one of his earliest steps was to make arrangements for a fresh series of observations of *Mars*, in connection with his former station in Santiago. These were carefully carried out and the results, when computed by Professors Hall and Ferguson, agreed in showing the accepted value of the solar parallax to be too small by more than a quarter of a second.*

Meanwhile, a series of observations made for the same purpose, by a different method, which had been employed by Henderson† for the opposition of 1832, and was again proposed‡ by Prof. Winnecke, of Pulkowa, in Russia, led to a similar result. Moreover, the distinguished French physicist, Foucault, by an exquisitely beautiful and ingenious series of experiments with a revolving

* *Washington Astron. Obs.*, 1863, p. xlv.

† HENDERSON, *Astr. Nachr.*, xi. 403.

‡ *Bulletin de l'Acad. de St Petersbourg*, 1862, May 2.

mirror, had made an actual measurement of the velocity of light, for which all our previous values had been inferred from the known time which light requires for coming to us from the sun (viz.: 8 m. 17·8 s.), combined with Encke's determination of the sun's distance. Now the tables were turned, and Foucault, finding the velocity of light to be somewhat less than had been supposed, inferred at once that the received value of the sun's distance was too large.* The value which he deduced accorded quite closely with the new values obtained from observations of *Mars*. And, strangely enough, a repetition† of Encke's computation of the transit of *Venus*, in 1769, using more accurate materials than had been at Encke's disposal, was found to give a value agreeing quite nearly with the other new determinations.

Prof. Newcomb, of Washington, has very carefully studied these various results, and has shown that the value of the solar parallax, which is deducible from Delaunay's‡ and Hansen's§ investigations of the moon's motions, and that also which may be derived from the perturbations of the earth's motion by the moon, agree with all the other recent results in showing Encke's value to have been considerably too small; although these means of inquiry are not among those best adapted for the purpose. He has fixed upon 8″·848 as the most probable value.‖ These several new results, as elaborated by him, are here presented in tabular form, from which it will readily be seen how surely the new value is superior to all previous ones.

Sun's Parallax.

	″	″
Encke, from the transits of Venus	8·5776	
From micrometric observations of Mars, 1862	8·842	+ 0·010
" meridian " " "	8·855	± 0·020
" new computation of transit of Venus, 1769	8·860	+ 0·040
" measures of velocity of light	8·860	
" parallactic inequality of the moon	8·838	+ 0·028
" lunar equation of the earth	8·809	+ 0·054
Most probable value	8·848	

This value seems likely to meet with general adoption for a good while to come, certainly till after the approaching pair of transits

* FOUCAULT, *Comptes Rendus*, lv. p. 537.

† POWALKY, *Neue Untersuchung des Venusdurchganges von* 1769, *zur Bestimmung der Sonnenparallaxe.* Kiel, 1864.

‡ *Delaunay*, *Theorie du mouvement de la Lune*, II. 847.

§ HANSEN, *Monthly Notices. R. Astr. Soc.*, XXIV. 8.

‖ NEWCOMB, *Washington Astron. Observations*, 1865, App. ii., pp. *1—*29.

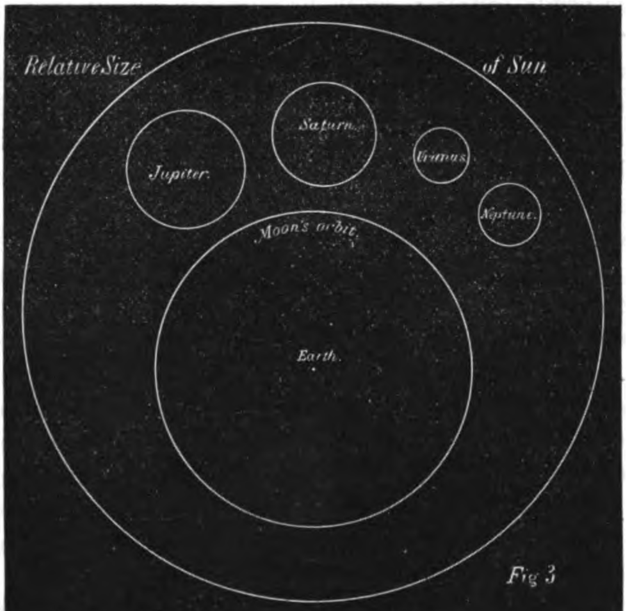
shall have been carefully observed and thoroughly computed. These will take place in 1874 and 1882, and astronomers are already preparing for the event, by investigating the most favorable points of the earth for observation, and taking measures for their occupation.

The actual mean distance of the sun corresponding to this parallax is 92,380,000 miles, and since his apparent diameter at this distance is 32′ 3″ (somewhat more than half a degree), we readily find the corresponding true diameter to be of the colossal size represented by 861,232 statute miles. This is nearly 109 times that of the earth, so that the earth, if seen from the sun, would appear but little more than $\frac{1}{12000}$ part as large as the sun appears to us. The velocity of light, in stellar space, corresponding to the new value of the sun's parallax, is at the rate of 185,600 miles in a second of mean time.

I have dwelt for some time upon the methods by which the sun's distance has been determined, for the sake of exhibiting the character of those modes of research to which we are indebted for our knowledge of the facts, and of showing the trustworthiness of the results attained. The disclosures of modern science are so astounding,—the scale of that portion of the universe to which the astronomer directs his attention, is so tremendous in comparison with all earthly magnitudes,—the quantities upon which their measurement depends, are in most cases so inconceivably minute, and the ingenuity of device which has guided the investigations is so wonderful—that a great demand is made upon the faith of those who have never devoted study to these subjects, when they are called upon to accept the results without question or distrust. The very processes employed in scientific researches rarely permit of satisfactory popular explanation; so that when such explanation is possible it seems desirable to show how firm the foundations are, upon which the established truths of astronomy are based.

To form some idea of the stupendous distances, magnitudes and velocities with which we thus become acquainted, let us compare them with some of those with which we are familiar. If we represent the earth by an ordinary rifle-bullet, the sun would be represented on the same scale by a globe 4½ feet in diameter, at a distance of 30 rods; but if we denote the earth by an orange of average size, the sun would appear as a globe 25 feet in diameter, half a mile off. We have seen that light, even with its inconceivable velocity, requires 8·3m. to traverse this enormous distance. An elec-

trical signal, traveling with the speed usual upon our telegraph wires, would put a girdle round the earth in about 1⅝ seconds, yet it would require 1h. 50m. to reach the sun. A locomotive engine, moving 40 miles an hour would consume 263½ years in traversing such a distance. And could we suppose an iron bar to extend from the earth to the sun, a blow or pull given at either end, no matter how violently, could not reach the other extremity for more than 345 days, although vibrations are transmitted through iron at the rate of about $3\frac{1}{10}$ miles (4,983 meters) in every second. The relative size of the sun is exhibited upon the diagram, which represents in true proportion the disks of the larger planets, the diameter of the earth, and the orbit of the moon traced upon a circle representing the fare of the sun. The proportional properties of the moon is less than of the line which represents her orbit.



For this diagram	the size	of the Sun	is given	by 1·5	inches	radius.
"	"	"	Moon's orbit	by 0·825	"	"
"	"	"	Earth	by 0·014	"	"
"	"	"	Jupiter	by 0·303	"	"
"	"	"	Saturn	by 0·275	"	"
"	"	"	Uranus	by 0·120	"	"
"	"	"	Neptune	by 0·144	"	"

The moon herself, with about ¼ diameter of earth, would be represented by less than the thickness of a line.

The apparent size of the earth if seen from the sun would be that of a circle whose radius is the amount of the sun's parallax; or just equal to that of a sphere $3\frac{8}{10}$ inches in diameter, seen from the distance of one mile.

(To be continued.)

SPECTRA OF METALLIC COMPOUNDS.

By Prof. A. R. Leeds.

The constant employment of the spectroscope in qualitative analysis renders it of great importance to detect and carefullly remove any attendant sources of error. Now, there are many other compounds, besides those of the alkalies and alkaline earths, which afford spectra, and a similarity in the position of their spectral lines and bands, causes them to be mistaken on cursory examination for spectra of certain of the alkaline elements. An examination of all the more important metallic compounds, and their faithful mapping, so far as they differed from each other, would eliminate this source of error. Such maps, moreover, would enlarge the field of application of the spectroscope, and enable us to detect the presence of many other bodies than those to which its use is at present restricted. A comparison of these spectra would set at rest many interesting points of inquiry and speculation. As for example, the amount and kind of alteration which takes place in the position, number and relative intensity of spectrum lines at various temperatures. For the variable influence—the temperature—being but one function of the spectrum, it is by no means to be concluded without experimental inquiry that the less and more refrangible parts of spectra alter *pari passu*. The fact that at high temperatures, decomposition takes place has already led (see memoir of M. Diacon, Ann. de Chim. [4], iv., 5) to a variety of interesting results. He found that in certain cases, when mixtures of volatile compounds were examined in the spectroscope, the spectrum obtained was not that of the compounds previously existent in the mixture, but that of the compounds which had been formed from their decomposition and subsequent recombination, according to the strength of their affinities at elevated temperatures. For example, a mixture of baryta and calcic chloride gave not only the spectra proper to these two compounds, but that of barytic chloride as well. The careful study of these changes would remove a source of em-

barassment in spectroscopic analysis. Moreover, it would probably furnish some information upon the chemistry of compounds, which we are wont to study in the solid state or in solution, when converted into vapors, and upon the phenomena of disassociation.

We already possess a very laborious and extensive series of determinations of the spectra of compounds by Prof. A. Mitscherlich (*Pogg. Ann.*, No. 3, 1864, and *Phil. Mag.* [4], September, 1864). He found that compounds of the first order, in so far as they are volatile and remain undecomposed when adequately heated, always exhibit spectra which differ completely from those of the metals. He obtained the spectra in a variety of ways. 1st. By evaporating solutions in a narrow flame of coal-gas or hydrogen. 2d. By bringing the substances into the flame of an oxygen-coal-gas burner. 3d. By bringing them into a hydrogen-chlorine burner. 4th. Evaporating bromine and iodine in hydrogen, and volatilizing the substance in the flame produced by the burning of this mixture in air or oxygen. 5th. By passing the gas to be examined either alone or in case it is not combustible, along with carbonic oxide or hydrogen, through the middle aperture of an oxyhydrogen burner, and burning the mixture in air or hydrogen. 6th. By volatilizing the substance in a current of hydrogen, and igniting the jet thus charged with the substance for examination. 7th. By passing the electric spark between electrodes of the metals or of their salts, when surrounded by an atmosphere of various gases. 8th. By using solutions of metallic salts as electrodes, and passing the spark from liquid to liquid.

It will be seen by a comparison of these methods, that they differ greatly with regard to the temperature at which the spectra are formed. It is much lower when, as in the first method, the solutions of the salts are volatilized, than when the fused salts themselves are used. In the latter case, the spectra are much more brilliant and persistent, and the lines are more numerous.

The third method was improved by Diacon, in that he surrounded his hydrogen-chlorine burner with a hood in such a way as to prevent the vaporized substance from coming into contact with the air. He thus obtained the spectra of the chlorides unmixed with the spectra of the corresponding oxides.

The feeble illumination in the green part of the spectrum, when hydrogen is burned in chlorine, may fairly be attributed, according to the same interpretation which we apply to the spectra of the

metals when burned in chlorine, to the chloride of hydrogen or hydrochloric acid, and the broad bluish-green, nebulous band when hydrogen is burned in air or oxygen, to the spectrum of aqueous vapor. The spectra of metals as obtained by Mitscherlich with the electric spark have been redetermined by Huggins and Miller with great care, and the lines obtained have been referred to a scale in which the atmospheric lines form fiducial points.

The maps given by Mitscherlich and Diacon, being referred to an arbitrary scale, are intelligible with difficulty. This difficulty applies not only to the position of the lines, but in a still greater degree, to their relative intensity and brightness. It was very much to be desired that the benefits of their labors should be made available to us in the present advanced state of spectroscopy, and an attempt was made to reduce their measurements to normal wave-lengths according to Angstrom's tables. But this was altogether impossible with Diacon's map, since the intervals had been micrometrically determined, and no comparison has been made with the solar or other standard lines. In Mitscherlich's maps, the lines *a*, α, D, E, *b* and F are marked, but when a graphical construction was attempted, by making the values of these points, as given in the maps, the ordinates and their corresponding wave-lengths, the abscissas of a curve, the curve was so irregular that the attempt had to be abandoned.

For obtaining the spectra of the metallic compounds, I have employed in the present investigation, the flame of a Bunsen burner, since it is to this source of heat that we refer our spectra in ordinary laboratory work. The resulting spectra are of two different kinds. In the case of oxygen salts, we obtain the spectra of the oxide of the metallic radical, the lines and bands being more or less broadened and brightened according to the degree of volatility of the salt. With haloid salts, we obtain the spectrum proper to the compound and also the spectrum of the oxide of the metallic radical. Two instruments were employed in the observations, one, a single prism spectroscope made by Desaga of Heidelberg, the other a five-prism direct-vision spectroscope made by Hofmann of Paris. Both were provided with arbitrary photographic scales. The numbers obtained in both cases were reduced to the scale accompanying the colored drawings of the metallic spectra, by Bunsen and Kirchhoff,* a dash between two numbers indicates a continuity of the spectrum between the points corresponding to them.

* Kα = 17·5, Na = 50·4, Li[illegible] = 31·8, Caα = 42, Caβ = 60·8, Srδ = 105.

Jour

Cu

$CuCl_2$+

H_2Cu_2O

CuO.

CuO_4

Cu C

Cu

Pb(NO

Pb C

72·2

5·9
4·5
7·8
2·2

65
1·3
5—
1—

6—

6—

4·5
2·2

8·5
2·7
92

6·5

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Table of Spectral Lines and Bands.

Substance.	Position of Lines according to Bunsen and Kirchhoff's Map.
Cuprous Oxide	37·8—44·8 60·8—72·4 78·2 84·1
Cupric Chloride with water	60·8—72·4
Cupric Carbonate............	39·5—43·8—46—47·6 60·5—62.7 67·5—74·6
Cupric Acetate...............	34·6 43·8—46 58 60·5—62·7 67·4 68·9—69·4 70 3—72·2
Cupric Sulphate......... ...	36·6 39·5—46 60·5 67·4 69·8 72·2 81·5 84—84·5
Cupric Chloride.............	31·8 37·8 40·2 41·4 45 52 60·8 65·5 68·9—73·6 75·9 —78·2 81·7 84·1—86·4 88·7—91 92·2 93·4 94·5 95·7 96·9 98—102·7 105 108·5 110·8 115·5 117·8 121·8 127·1 127·1 129·4 130·6 134·1 136·4 142·2 144·5
Cupric Iodide	33·6 34·6 36·6 39 41 42·1—43·2 45·5—46 62·7 65 66·5 68·9—69·9 71·8 73·2 75·1 76 77·5 79 81·3 82·2 83·2 85·1—86·5 89·8—91 94·2—95·7 98·5—100 102—103·5 104·8 107·3 109·1—111·1 114·1—116·1 119·1—120·6
Plumbic Peroxide	55 5—58·5 59 5—64·2 66·5—68·4 69·9—71·8 73·6—76 80·3—83·2
Plumbic Carbonate.........	39—43·8 46—48·6 53—56·5 58·5—59·5 61·5 63·7 66—67·9 69·4—70·8 72·7 76 79·3—82·3 84·1 86·5
Plumbic Nitrate............	34·6 37·6—40·5 41·1—43·8 46—48·1 49·1—49·6 54·5 55·5—57·58—59 60·5—64·2 66·5—67·9 69·9—72·2 74·6 76·5 79·3—82·7 88·8—91·5
Plumbic Chloride............	35·6—40·5 41·6—42·7—43·8 47—48·1 55—57 58·5 60·5—63·7 66—66·5—68·4 69·4—71·3 72·2 72·7 74·1 76·5 77 81·8 82·2 83·2 84.6 86·5 90 3 92 96·2 101 105·8 108·6
Manganous Chloride.......	40·2—42·6 47·4—49·8 57—59·4 62—64·3 —65·5—66·5 68·9—74·8 75·9—84·1
Cadmic Nitrate...............	71·3—72·2 75·5—78 80·3—81·8 88·5—89·8

In the accompanying map of the spectra of metallic compounds the distances on the horizontal divisions of the scale are taken as abscissas, and the relative intensities of the lines and bands as ordinates. It will be seen by comparison of the spectra of the oxygen salts of copper that there is a close similarity between them. Indeed, it is probable that if the drawing had been made directly from the instrument, instead of from notes taken of observations and used in drawing afterwards the spectra would have been almost identical. The differences would have consisted merely in the breadth and brightness of the lines. But between the spectra of the oxygen and haloid salts, and between the haloid salts themselves, the differences are numerous and striking. In addition to the lines in the less refrangible portion of the spectrum, which are common to all, and which belong to the metal as oxide, a great number of lines in the green, blue, indigo and violet are seen, whose form and grouping are peculiar to the haloid salt under examination. In the spectrum of cupric

chloride, the most noticeable feature is the grouping of the lines, in the more refrangible end of the spectrum, into pairs, in which the broader and more conspicuous lines are separated by an interval of about six degrees, while to their right, at a distance of about one degree, another but much feebler line in each case is seen. In the spectrum of cupric iodide no such symmetrical arrangement is evident. With plumbic chloride the same extension of the lines into the upper end of the spectrum takes place. Many of the bands in the spectra of the plumbic salts are beautifully shaded, and commence with a feeble illumination on the side toward the less and increase to a line of maximum brightness on the side toward the more refrangible end of the spectrum, where they abruptly terminate.

Without detailing in this place, what takes place when the various metallic compounds are examined, it will be interesting to note briefly the deportment of one of them—cupric chloride. When a mass of this salt, which has not previously been freed from water of crystallization, is heated on a platinum wire in the flame of a Bunsen burner, it imparts in the first place a greenish illumination to a large portion of the flame. On examining the flame through dark blue glass, it is seen that the part immediately above the heated substance is of a deep blue color. This becomes tinged with violet, and later a tongue of reddish flame rises in the centre of the blue. If the substance be pushed into the hotter part of the burner, this flame changes to a bright white light, which at its upper edge becomes lurid again. The spectrum in this case is continuous throughout the middle and lower portion, the separate bands of violet still remaining distinct.

It is evident that we have been studying phenomena of a mixed character. When we carefully heat a mass of this salt, so that it is slowly volatilized along with aqueous vapor at the outer edge of the flame, a green band, extending from 60·8 to 72·4, alone makes its appearance. If we heat a concentrated solution of cupric chloride, the red lines from 37·8—44·8 appear synchronously with the green from 60·8 to 72·4. It is only at higher temperatures that the great number of lines in the blue and violet make their appearance, and it is not until the salt is fused that the spectrum becomes continuous. We do not, in this case, attribute the continuity of the spectrum to the diffusion of incandescent particles of the solid substance throughout the flame, but to the widening out of the bands

in every part of the spectrum until their fusion produces white light.

At a future time we hope to replace this preliminary essay by more carefully prepared drawings, and by a more extended table of the lines referred in position to normal wave-lengths, and in intensity to the solar spectrum taken as a standard.

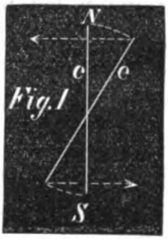
ABSOLUTE SYSTEM OF ELECTRICAL MEASUREMENTS.

BY JOSIAH P. COOKE, JR.

(Continued from page 140.)

THESE two forces would form a couple acting with a leverage equal to one-half the length of the needle, so long as the needle remains in the meridian. Hence the effect of the couple would be represented by $\frac{\text{C L } m\, l}{k_2}$, where $m\, l$ represents the magnetic moment.

When deflected to an angle d the force would act as strongly as ever, but the effect of the couple on the needle would be diminished because the moment is not now $m\, l$, but $m\, l$ cos. d.



The strength of the couple now, is therefore—

$$\frac{\text{C L } m\, l}{k_2} \cos. d.$$

When the needle comes to equilibrium the effect of this couple is exactly balanced by a second couple created by the earth's magnetism. The space in which our experiments are made is a magnetic field of uniform intensity, the direction of the forces in that field are sensibly parallel, and the intensity of that field is capable of measurement. The directions of the lines of force are shown by a dipping needle, but as a magnetic needle is usually hung so that it can only move in a horizontal plane, it is usual to estimate only the horizontal force of the earth's magnetism, which we will represent by H.* The effect of the earth's magnetism on a pole would be m H, and the effect of the magnetic couple on our needle when pointing E—W, would be

* The mean horizontal component for 1862 at Kew, in England, was 1·7592 units, *i. e.*, a unit pole weighing 1 gramme, and free to move in a horizontal plane would acquire under the earth's magnetism a velocity of 1·7592 metres a second.

$\text{H}\,m\,l$, while the effect of the same couple on the needle making an angle d with the meridian would be $\text{H}\,m\,l\sin.\,d$. But since the magnetism of the earth is assumed to just balance the magnetic couple, we have—

$$\frac{\text{C L}\,m\,l}{k^2}\cos.\,d = \text{H}\,m\,l\sin.\,d,$$

Whence we easily deduce—

$$\text{C} = \frac{\text{H}\,k^2}{\text{L}}\,\text{tang.}\,d, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [7]$$

An instrument called the tangent galvanometer fulfills all the conditions referred to above. Hence with this instrument we can always determine the value of C in electro-magnetic absolute units, and thus fix the unit current. We can readily determine for any galvanometer at a given time and place the angle of deflection, which the unit current would produce, and then by the rule of tangents, determine the value of all other currents in terms of this unit.

Thus fixing the unit of current we find by [3] the unit of resistance, by [2] the unit of quantity, and by [1]* the unit of electromotive force.

6. The quantity of electricity in a condenser, for example a Leyden Jar, may be measured by observing the swing of a galvanometer needle produced by allowing the charge to pass through the coil of a galvanometer in a time extremely short, compared with that occupied by an oscillation of the needle. The magnetic force exerted by the current may then be regarded as giving a single sudden impulse to the needle, and the strength of this impulse may be measured by the velocity, which the needle acquires on its return swing. As in the case of the pendulum this velocity is easily estimated from the amplitude of the oscillation.

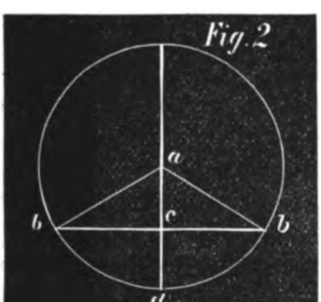


Fig. 2

In the case of the pendulum the velocity acquired in oscillating from b to d would be the same that a freely falling body would acquire in falling vertically from c to d. Calling this vertical distance d, we have—

$$\text{V} = \sqrt{2\,g\,d},$$

* It is also true that a unit current in a straight wire, one metre long, repels another similar current in a parallel wire of the same length one metre distant, with the unit of force.

but d being the versed sine of the angle $b\,a\,c$, we have, when the radius is unity, and the angle i;

$$d = \sqrt{2\,g\,(1 - \cos. i)}$$
$$= \sqrt{g} \times 2 \sin. \tfrac{1}{2}\, i.$$

In the case of the magnetic needle the intensity of gravity is exchanged for the directive force of the earth's magnetism whose influence may be regarded for the time being, as a constant quantity. Moreover since the quantity of electricity in an instantaneous current is proportional to the velocity thus imparted we shall have—

$$Q : Q' = \sin. \tfrac{1}{2}\, i : \sin. \tfrac{1}{2}\, i'$$

Again, calculation shows that the value of Q may be referred to the strength of the continuous current C, which gives the unit deflection (45°) on a tangent galvanometer by the formula—

$$Q = Q\, \frac{C_1\, t}{r} \sin. \tfrac{1}{2}\, i, \qquad \qquad [8]$$

where t is the time of a half-oscillation.

The electro-capacity of a conductor is the quantity of electricity with which it can be charged by the unit of electromotive force. Hence—

$$S = \frac{Q}{E}, \qquad \qquad [9]$$

When the electromotive force producing the charge, is capable of maintaining a current the capacity of the conductor may be obtained without the knowledge either of Q or E, provided we have the means of measuring the resistance of a circuit in electro-magnetic units. Let R_1 be the resistance of the circuit in which the given electromotive force will produce the unit deflection on a tangent galvanometer than from equations [1] and [8], we have—

$$S = Q\, \frac{t \sin. \tfrac{1}{2}\, i}{r\, R_1}, \qquad \qquad [10]$$

7. To recapitulate the electro magnetic *unit of current* produces the unit force on a unit pole, at the unit distance, in the unit length of conductor.

The unit current conveys the *unit quantity* of electricity through the unit resistance in the unit time.

The unit current flowing through a conductor of *unit resistance*, produces an effect equivalent to the unit of work in the unit of time.

The unit current will be produced in a circuit of the unit of resistance, by the unit of *electromotive force.*

The *unit quantity* falling in tension, the unit of *electromotive force* does the unit of work. This last relation is, however, involved in the previous three.

8. *Names of Units.*

The units above defined are known as the *electro-magnetic absolute units*, but although exceedingly convenient as aids in calculation, they would be wholly unsuitable as practical measures of electrical quantities. These quantities are of an entirely different order of magnitudes from those which we are accustomed to measure by metrical units.

Farads.—The most powerful current ever obtained by a voltaic combination is far less than the absolute electro-magnetic unit of current, it would therefore be absurd* to adopt this unit as our ordinary measure. It has been agreed to adopt as the unit of current for ordinary purposes the 10^{-8} or $\frac{1}{100,000,000}$th part of the absolute unit. This unit we will call the B. A. unit. The quantity of electricity which such a current would discharge per second is called *farad* (named from Faraday). Hence the B. A. unit of current is a current of one farad per second. The farad is, therefore, also the 10^{-8} part of the absolute unit of quantity. We also speak of Megafarads = one million farads, and Microfarads = the one millionth of a farad.

Ohms.—As the absolute units of quantity are far too large for ordinary uses, so also the absolute unit of resistance is far too small. The British Association have adopted as the ordinary measure a unit called the Ohm, which equals 10^7, (ten million) absolute units. We use also Megohm = one million ohms, and the Microhm = one-millionth of an Ohm. 48·61 metres standard copper or silver wire, 1 m.m diameter has a resistance of an Ohm at 65°.

Volts.—The British Association have adopted as the ordinary unit of tension the Volt, which equals 10^5 or 100,000 absolute units of tension, and we employ also Megavolts and Microvolts as before. A Daniel's cell has an electromotive force of about 1 volt. According to Thompson 1 volt. = 0·9268 of Daniell's cell or Daniell's cell = 1·079 volts.

* The definitions on which the absolute unit of current is based, involve magnitudes never met with in practice. A unit pole cannot be realized experimentally and is therefore merely a convenient fiction.

The above names have been very appropriately given, since Ohm investigated the influence of resistance on electrical currents. Volta invented the battery by which electrical tension is obtained and Faraday more especially investigated the relations of electrical quantity.

9.—*Table.*

The Ohm	is 10^7	absolute	units	of resistance.
The Megohm	is 10^{13}	"	"	"
The Microhm	is 10	"	"	"

Ohm = 48·61 metres Cu or Ag wire, 1 m.m. diameter.

The Volt	is 10^5	absolute	units	of electro-motive force.
The Megavolt	is 10^{11}	"	"	"
The Microvolt	is 10^{-1}	"	"	"

Electro-motive force of Daniell's cell = 1·079 Volt.

The Farad	is 10^{-8}	absolute	unit	of quantity.
The Megafarad	is 10^{-2}	"	"	"
The Microfarad	is 10^{-14}	"	"	"

The units of current carry the units of quantity each second.

In using these units it must be constantly borne in mind that the letters C, E, R, Q, W, &c., given in the formulæ of the previous sections, stand in all cases for the absolute units. In calculating therefore, with B. A. units, we must substitute their values in absolute units given in the above table.

Problem.—To find the current through one ohm with a tension of one volt.

$$C = \frac{E}{R};\ \text{gives } C = \frac{10^5}{10^7} = 10^{-2}.$$

Ans.—One Megafarad per second.

Problem.—To find the work done by a current of one megafarad through a resistance of an ohm.

$$W = C_2\, R\, t;\ \text{gives } W = (10^{-2})^2 \times 10^7 = 10^3.$$

Ans.—10,000 absolute units per second.

Problem.—To find the work done by one farad of electricity in falling in tension one volt.

$$W = Q\, E;\ \text{gives } W = 10^{-8} \times 10^5 = 10^{-3}.$$

Ans.—$\frac{1}{1000}$ unit of work. Hence 1000 volt-farads equals 1 unit of work, and 9800 volt-farad equals 1 metre gramme.

10. *Dimensions of Units.*

It has been shown that the units of electrical measurements may be directly referred to the fundamental units of space, weight and time—the metre, the gramme and the second; in other words, may be expressed in terms of these three quantities, and of these alone. In order to show more clearly what the relation of each is, it is proposed to give the values of the several electrical units in terms of $L =$ length. $M =$ mass or weight. $T =$ time.

$$\text{Velocity} = V = \frac{L}{T}.$$

$$\text{Force} = F = \frac{M\,V}{T} = \frac{M\,L}{T^2}.$$

$$\text{Work} = W = F\,L = \frac{M\,L^2}{T^2}.$$

$$\text{Work in metregrammes} = \frac{M\,L^2}{T^2}.\ \frac{1}{9{\cdot}808}.$$

$$\text{Strength of pole}^* = m = \frac{L^{\frac{3}{2}}\,M^{\frac{1}{2}}}{T}.$$

$$\text{Strength of current}^\dagger = C = \frac{L^{\frac{1}{2}}\,M^{\frac{1}{2}}}{T}.$$

$$\text{Quantity of electricity} = Q = C\,T = L^{\frac{1}{2}}\,M^{\frac{1}{2}}.$$

$$\text{Electromotive force} = E = \frac{W}{Q} = \frac{M^{\frac{1}{2}}\,L^{\frac{3}{2}}}{T^2}.$$

$$\text{Resistance} = R = \frac{E}{C} = \frac{L}{T} = V.$$

(To be continued.)

Identity of Artificial with Natural Alizarine.—The crystallization of both is similar. Dissolved in caustic alkali bath form violet solutions of the same tint. When applied to mordanted fabrics they produce the same colors, bearing soap equally well. When examined with the spectroscope, their potassic solutions show the same absorption bands.

* This value is readily obtained by considering that the force exerted between two poles must be— $F = \frac{m\,m^1}{D^2}$ or $= \frac{m^2}{D^2}$, when the two poles are equal. Hence— $m = D\sqrt{F}$.

† Readily derived from value of C by [5].

CHEMICAL TABLES ACCORDING TO THE THEORIES OF MODERN CHEMISTRY.

BY PROF. LEEDS.

(Continued from page 49.)

TABLE II.—*Atomic Weights, according to the most important works upon Chemistry.*

H = 1. Rammelsberg has O = 100.

ELEMENT.	Ancient Chemistry.					Transition.	Modern.		
	Graham.	Miller.	Gmelin.	Rammelsberg.	Fresenius.	Watts.	Williamson.	Wurtz.	Cooke.
Aluminum	13·69	13·7	13·7	171·	13·75	13·75	27·5	27·	27·4
Antimony	129·08	12·2	129·	1504·	122.	120·3	122·	122·	122·
Arsenic	76·	75·	75·2	940·	75·	75·	75·	75·	75·
Barium	68·64	68·5	68·6	857·	68·6	68 6	137·	137·	137·
Bismuth	70·95	210·3	106·4	2600·	208·	210·	210·	210·	210·
Boron	10·9	10·9	10·8	136·2	11·	11·	11·	11·	11·
Bromine	78·26	80·0	78·4	1000·	80	80·	80·	80·	80·
Cadmium	55·74	56·0	55·8	696·8	56·	56·	112·	112·	112·
Cæsium	....	....	....	....	133·	....	133·	....	133·
Calcium	20·	20·	20 5	250·	20·	20·	40·	40·	40·
Carbon	6·	6·	6·	75·	6·	12·	12·	12·	12·
Cerium	46·	46·	46 3	575·	....	46·	92·	....	92·
Chlorine	35·5	35·5	35 4	443·3	35·46	35·5	35·5	35·5	35 5
Chromium	28·15	26·8	28·1	329·	26·24	26·2	52·5	53·5	52 2
Cobalt	29·52	29·5	29·6	375·	29·50	29·5	58·5	59·	58·8
Columbium	....	48·8	....	611·	....	97·6	195·	....	94·
Copper	31·66	31·7	31·8	396·6	31·7	31·7	63·5	63·5	63·4
Didymium	49·6	48·	....	....	....	48·	96·	....	95·
Erbium	....	....	....	....	....	....	....	....	112·6
Fluorine	18·7	19·	18·7	237·5	19·	19·	19·	19·	19·
Glucinum	26·5	4·7	17·7	86·5	....	4·7	9·	....	9·3
Gold	98·33	196·6	199·	2458·	196·	196·	196·	197·	197.
Hydrogen	1.	1·	1·	12·5	1·	1·	1·	1·	1·
Indium	....	....	....	....	....	....	74·	....	72·
Iodine	126·36	127·	126·	1586·	....	127·	127·	127·	127·
Iridium	98·68	98·6	98·7	1232·	127·	98·6	197·	198·	196·
Iron	28·	28·0	27·2	350·	....	28·	56·	56·	56·
Lanthanum	48·	46·0	36·1	580·	28·	46·	92·	....	93·6
Lead	103·56	103 6	103·8	1294·6	....	103·6	207·	207·	207·
Lithium	6·43	7·0	6·4	82·5	108·5	67·	7·	7·	7·

TABLE II—*Continued.*

ELEMENT.	Ancient Chemistry.					Transition.	Modern.		
	Graham.	Miller.	Gmelin	Rammelsberg.	Fresenius.	Watts.	Williamson.	Wurtz.	Cooke.
Magnesium.........	12·67	12·16	12·7	150·	12·	12·	24·	24·	24·
Manganese..........	27·67	27·5	27·6	337·5	27·5	27·6	55·	55·	55·
Mercury............	100·07	100·	101·4	1250·	100·	100·	200·	200·	200.
Molybdenum.......	47·88	48·	48·	575·	46·	46·	96·	96·	96·
Nickel..............	29·57	29·5	29·6	362·5	29 5	29·	58 5	59·	58·8
Nitrogen...........	14·	14·	14·	175·	14·	14·	14·	14·	14·
Osmium.............	99·56	99·4	99·6	1250·	....	100·	199·	199·2	199·2
Oxygen..............	8·	8·	8·	100·	8·	16·	16·	16·	16·
Palladium...........	53 27	53·2	53·4	664·	53·	53·	106 5	106·6	106·6
Phosphorus	32·02	31·0	31·4	387·5	31·	31·	31·	31·	31·
Platinum............	98·68	98·6	98·7	1237·5	98·94	99·	197·	197·5	197·4
Potassium...........	39·0	39·0	39·2	489·	39·11	39·	39·	39·1	39·1
Rhodium............	52·11	53 2	52·1	650·	....	52·	104·	104·4	104·4
Rubidium...........	....	....	....	....	85·4	....	85·	....	85 4
Ruthenium..........	52·11	53·	51·7	650·	....	52·	104·	104·4	104·4
Selenium............	39·57	39·7	40·	495·3	39·5	79·	79·5	79·5	79·4
Silicon..............	21·35	14·	14·8	185·	14·	28·	28·	28·	28·
Silver................	108·	108·	108·1	1350·	107·97	108·	108·	108·	108·
Sodium..............	22·97	23·	23·2	287·5	23·	23·	23·	23·	23·
Strontium...........	43·84	43 8	44·	548·	43·75	43·8	87·5	87·5	87·6
Sulphur..............	16·	16·	16·	200·	16·	32·	32·	32·	32·
Tantalum...........	92·3	68·8	185·	860·	....	37·6	138·	....	182·
Tellurium...........	66·14	64 5	64·	802·	....	128·	....	129·	128·
Terbium	....	....	....	....	....	....	....	....	....
Thallium............	....	....	....	....	203·	....	203·	....	204·
Thorium............	59·59	59 5	59·6	744·	....	59·5	238·	....	231·4
Tin..................	58·82	59·	59·	735 3	59·	116·	118·	118·	118·
Titanium....	24·29	25·	24·5	300·	25·	50·	50·	50·	50·
Tungsten............	94·64	92·	95·	1150·	....	92·	184·	184·	184·
Uranium............	60·	60·	217·	743·	59·4	60·	120·	120·	120·
Vanadium	68·55	68 5	68·6	856·8	....	68·5	137·	68 6	51·37
Yttrium..............	32 2	....	32·2	437·5	....	....	64·	....	61·7
Zinc..................	32·52	32·6	32·2	406·6	32·53	32·5	65·	65·2	65·2
Zirconium	33·62	33·6	22·4	558.5	....	33·5	89·5	89·6	89·6

TABLE III.

Revised Atomic Weights according to the Ancient Chemistry. H = 1.

ELEMENT.	Atomic Weight.	Authority.	ELEMENT.	Atomic Weight.	Authority.
Aluminum.......	13·74	Dumas.	Manganese.......	27·48	Dumas.
Antimony.......	122·34	Dexter.	Mercury..........	100·1	Erdmann and Marchand.
Arsenic.......	75·00	Pelouze.			
Barium...........	68·51	Dumas.	Molybdenum....	48·	Dumas.
Bismuth...........	210·34	"	Nickel...........	29·51	"
Boron..............	11·00	"	Nitrogen.........	14·	"
Bromine..........	79·97	De Marignac.	Osmium.........	99·4	Berzelius.
Cadmium........	56·	C. v. Hauer.	Oxygen...........	16·	Dumas.
Cæsium............	133·	Johnson and Allen.	Palladium.......	53·28	Berzelius.
			Phosphorus......	31·	Schrötter.
Calcium...........	20·01	Dumas.	Platinum........	98·94	Andrews.
Carbon............	6·00	"	Potassium.......	39·13	Stas.
Cerium............	45·644	C. Wolf.	Rhodium.........	52·16	Berzelius.
Chlorine..........	35·5	Dumas.	Rubidium........	85·4	Bunsen.
Chromium........	26.27	Berlin.	Ruthenium......	52·1	Claus.
Cobalt.............	29·54	Dumas.	Selenium.........	39·62	Berzelius.
Columbium.......	49·225	Rammelsberg.	Silicon............	14·01	Dumas.
Copper.............	31·72	Erdmann and Marchand.	Silver.............	107·95	Stas.
			Sodium...........	23·05	"
Didymium........	47·92	De Marignac.	Strontium......	43·74	Dumas.
Erbium............	56·3	Bahr & Bunsen	Sulphur..........	16·	"
Fluorine..........	19·	Louyet.	Tantalum........	91·	Rammelsberg.
Glucinum.........	9·29	Awdejew.	Tellurium.......	64·5	Dumas.
Gold................	196·78	Berzelius.	Terbium..........	87·68	Delafontaine.
Hydrogen.........	1.	Dumas.	Thallium.........	204·	Lamy.
Indium............	37·818	Winkler.	Thorium.........	50·5	Berzelius.
Iodine.............	127·	Dumas·	Tin................	59·03	Dumas.
Iridium...........	98.56	Berzelius.	Titanium.......	25·17	Pierre.
Iron................	28·	Erdmann and Marchand.	Tungsten........	92·	Dumas.
			Uranium.........	59·48	Ebelmen.
Lanthanum.......	46·4	Mosander.	Vanadium.......	51·38	Roscoe.
Lead...............	103·5	Dumas.	Yttrium.........	30·85	Bahr & Bunsen
Lithium...........	7·	Troost.	Zinc...............	32·53	Erdmann.
Magnesium.......	12·3	Dumas.	Zirconium.......	33·6	Berzelius.

Table IV.

Atomic Weights according to the Modern Chemistry.

ELEMENT.	Quantivalence.	Atomic Symbol.	Atomic Weight.	Logarithm.	Ar. Co.
Aluminum	II. or IV.	Al.	27·48	1·43902	8·56098
Antimony	III. or V.	Sb.	122·34	2·08757	7·91243
Arsenic	III. or V.	As.	75·	1·87506	8·12494
Barium	II.	Ba.	137·02	2·13678	7·86322
Bismuth	III. or V.	Bi.	210 34	2·32292	7·67708
Boron	III.	B.	11·	1 04139	8·95861
Bromine	I.	Br.	79·97	1·90298	8·09707
Cadmium	II.	Cd.	112·	2·04922	7·95078
Cæsium	I.	Cs.	133·	2·12385	7·87615
Calcium	II.	Ca.	40·02	1·60228	8·39772
Carbon	IV.	C.	12·	1·07918	8·92082
Cerium	II.	Ce.	91·33	1·96061	8·03939
Chlorine	I.	Cl.	35·5	1·55023	8·44977
Chromium	II. or IV.	Cr.	52·54	1·72049	8·27961
Cobalt	II.	Co.	59·08	1·77144	8·22856
Columbium	V.	Cb.	98 45	1·99322	8·00678
Copper	II.	Cu.	63 44	1·80236	8·19764
Didymium	II.	D.	95·84	1·98155	8·01845
Erbium	II.	E.	112 6	2·05154	7·94846
Fluorine	I.	F.	19·	1·27875	8·72125
Glucinum	II.	G.	9 29	0·96802	9·03198
Gold	III.	Au.	196·73	2·29387	7·70613
Hydrogen	I.	H.	1·	0·00000	10·00000
Indium	II.	In.	75·63	1·87869	8·12131
Iodine	I.	I.	127·	2·10380	7·89620
Iridium	II. or IV.	Ir.	197·13	2 29476	7·70524
Iron	II. or IV.	Fe.	56·	1 74819	8 25181
Lanthanum	II.	Ln.	92·8	1·96755	8·03245
Lead	II.	Pb.	207·	2·31597	7·68403
Lithium	I.	L.	7·	0·84510	9·15490
Magnesium	II.	Mg.	24·6	1·39094	8·60906
Manganese	II. or IV.	Mn.	54·96	1·74005	8·25995
Mercury	II.	Hg.	200·2	2·30146	7·69854
Molybdenum	VI.	Mo.	96·	1·98227	8·01773
Nickel	II.	Ni.	59 02	1·77100	8·22900

TABLE IV.—*Continued.*

ELEMENT.	Quantivalence.	Atomic Symbol.	Atomic Weight.	Logarithm.	Ar. Co.
Nitrogen............	III. or V.	N.	14·	1·14613	8·85387
Osmium	II. or IV.	Os.	198·8	2·29842	7·70158
Oxygen............	II.	O.	16·	1·20412	8·79588
Palladium............	II. or IV.	Pd.	106·56	2·02760	7·97240
Phosphorus............	III. or V.	P.	31·	1·49136	8·50864
Platinum............	II. or IV.	Pt.	197·88	2·29641	7·70359
Potassium............	I.	K.	39·13	1·59251	8·40749
Rhodium............	II. or IV.	R.	104·32	2·01836	7·98164
Rubidium............	I.	Rb.	85·4	1·93146	8·06854
Ruthenium............	II. or IV.	Ru.	104·2	2·01787	7·98213
Selenium............	II. or VI.	Se.	79·24	1·89894	8·10106
Silicon............	IV.	Si.	28·02	1·44747	8·55253
Silver............	I.	Ag.	107·95	2·03322	7·96678
Sodium	I.	Na.	23 05	1·36267	8·63733
Strontium............	II.	Sr.	87·48	1·94191	8 05809
Sulphur............	II. or VI.	S.	32·	1·50515	8·49485
Tantalum............	V.	Ta.	182·	2·26007	7·73993
Tellurium............	II. or VI.	Te.	129·	2·11059	7·88941
Terbium............	....	Tb.	75 36	1 87714	8·12286
Thallium	I. or III.	Tl.	204·	2 30963	7·69037
Thorium............	IV.	Th.	238·	2 37658	7·62342
Tin............	II. or IV.	Sn.	118·06	2·07210	7·92790
Titanium............	II. or IV.	Ti.	50·34	1·70191	8·29809
Tungsten	VI.	W.	184·	2 26482	7·73518
Uranium............	III. or V.	U.	118·86	2·07510	7·92490
Vanadium	III. or V.	V.	51 33	1·71037	8·28963
Yttrium	II.	Y.	61 7	1·79029	8·20971
Zinc............	II.	Zn.	65 06	1 81331	8 18669
Zirconium............	IV.	Zr.	89·6	1·95231	8·04769

(To be continued.)

Important Synthetical Reaction.—Dr. E. Royer announces that, while passing a current of electricity through an aqueous solution of carbonic acid, it was converted into formic acid, upon adding hydrogen.

ON THE NEW CHEMICAL NOMENCLATURE.

BY DR. ADOLPH OTT.

(Continued from page 132.)

BEFORE entering fully on the discussion of the adaptability of the new chemical nomenclature to organic bodies, it seems essential to say a few words on the new doctrine of types and substitutions. As Professor Tillman has explained it very clearly and satisfactorily with his new symbols, and given some original views in relation thereto, I propose to avail myself of his own statement of the more prominent points under consideration.

"1. An atom has a definite maximum power of holding other atoms in chemical union. The normal quantivalences, or highest saturating capacity of an atom, that is, its so-called atomicity, decreases as it is duplicated and condensed.

"2. *Chlorad* is ranked in the class of elements having the lowest saturating power: therefore *ad* may be taken as the unit of measurement, and thus words already in use in this connection are made peculiarly appropriate; for example, *hydral* is a monad, *oxat* is a dyad, *nitran* is a triad (often a pentad), *carbar* is a tetrad, *phosap* is a pentad and often a triad. *Carber*, *Ferrem*, *Alem*, *Chromem*, and other DOUBLE ATOMS forming sesquioxides, behave like hexads, while *Manam* appears to be a heptad. *Arsam*, *Bisam* and *Stibam* are either triads or pentads.

"3. A molecule is a complete chemical structure, capable of existing in a separate state; that part of it which can unite with various monad radicals—known as the residue or remainder of a molecule—being regarded as a broken structure or imperfect body, may be called a *torso*.

"4. The atomicity of a torso, or of a radical containing one atom of an element united to one or more atoms of another element, is equal to the *difference* between the normal saturating power of its components. The following are examples:—

COMPOUND MONADS.

Ammonium, H_4N''' = *olan* or *ilanal'*; Hydroxyl, $H'\mathbf{O}''$ = *alt'*;
Amidogen, H_2N''' = *elan'*; Nitric oxide, $N'''\mathbf{O}_2''$ = *anet'*;
Cyanogen, $\mathbf{C}^{iv}N'''$ = *arn'*;

COMPOUND DYADS.

Carbonyl (Carbonic oxide), $C^{iv}O''$ = *arat* or *art''*:
Monamine, HN''' = *alan''*; Methylene, $\mathbf{C}^{iv}H_2$ = *arel* or *ach''*.

COMPOUND TRIADS.

Formene, $\mathbf{C}^{\text{iv}}\mathbf{H} =$ *arl'''*; Phospil, $\mathbf{P}^{\text{v}}\mathbf{O}'' =$ *apt'''*.

"5. The researches of KEKULE have shown that the same number of carbon and hydrogen atoms, having different saturating powers, are related to different hydrocarbon series; and the equivalence of such isomers may be determined by the number of hydrogen atoms they contain. For example, glyceryl $\mathbf{C}_3 H_5$ (*echarl'''*), having three less hydrogen atoms than the hydride of propyl (*ichel*), $\mathbf{C}_3 H_8$ is a triad; while allyl, $\mathbf{C}_3 H_5$ (*arechal'*), having one atom of hydrogen less than propylene, $\mathbf{C}_3 H_6$ (*irlil''*) is a monad. Thus also to the series of highest saturation of carbon belongs acetylene, $\mathbf{C}_2 H_2$ (*erel* or *erl*$^{\text{iv}}$); and having four atoms of hydrogen less than the hydride of ethyl $\mathbf{C}_2 H_6$ (*echel*), it is a tetrad. If two atoms of the monad bromine be added, the saturating power of the compound will be diminished two degrees; therefore the bibromide of acetylene, $C_2H_2Br_2$ (*erleb*) is a dyad. The late brilliant elucidations of atomicity by Professor WURTZ, of the college of France, have thrown light on many points, to which reference cannot now be made.

"6. A complex hydrocarbon monad radical may be regarded as the combination of a monad with an even number of radicals or torsoes *in equilibrio*. The following are examples:—

Acetyl $= (\mathbf{CO}'' \, \mathbf{CH}_2'') + \mathbf{H} =$ *artachal'*.
Propyl $= (\mathbf{CH}_2'' \, \mathbf{CH}_2'') + \mathbf{CH}_3' =$ *ichal'*.
Butyl $= (\mathbf{CH}_2'' \, \mathbf{CH}_2'' \, \mathbf{CH}_2'' \, \mathbf{CH}_2'') + \mathbf{H} =$ *ochal'*.

"7. GERHARDT classified chemical compounds under four types, two of which, the hydrogen and hydrochloric-acid types, are molecules consisting of two monads; one molecule should therefore be taken as the primal type, and the other as a sub-type. The use of only three types would, at first sight, be commended for its simplicity; yet the vast diversity of nature's combinations involves the necessity of many multiples, and the formation of mixed types as proposed by ODLING, in which the saturating power of the several parts is distinguished by the signs used in this paper. Valid arguments may be urged in favor of using at least five types, in each of which, one-half the saturating power expended to form the molecule is derived from a single atom. The atom-holding power of one-half being balanced by that of the other half of each molecule, it is proposed to distinguish each type by the name expressing the equivalence of one-half of it. The following will show the value of the new characters in typical expressions:

MONAD TYPE.	DYAD TYPE.	TRIAD TYPE.	TETRAD TYPE.	PENTAD TYPE.
Hydrochloric Acid. $al \} ad$	Water. $\left.\begin{matrix} al \\ al \end{matrix}\right\} at$	Ammonia. $\left.\begin{matrix} al \\ al \\ al \end{matrix}\right\} an$	Marsh gas. $\left.\begin{matrix} al \\ al \\ al \\ al \end{matrix}\right\} ar$	Chloride of phosphorus. $\left.\begin{matrix} ad \\ ad \\ ad \\ ad \\ ad \end{matrix}\right\} ap$

In representing the most important bodies formed by the replacement of one or more atoms of hydrogen by one or more monad radicals, the change consists, as will presently be shown, simply in substituting for *al* the name of a radical ending with *al.* The different views of chemists respecting the typical form of the same body may be distinctly illustrated by the new characters; take, for example, acetic acid, $C_4H_4O_4 = \mathbf{C}_2H_4\mathbf{O}_2$. KOLBE's carbonic acid type, being essentially the same as the water type, is omitted, and the so-called radical type is added in the following table. In the latter type two atoms of the tetrad, carbon, are supposed to have their total atomicity contracted from octad to hexad.

EMPIRICAL.	GERHARDT.	DEBUS.	FRANKLAND & DUPPA.
olert or *echet*	$\left.\begin{matrix} al \\ artachal \end{matrix}\right\} at$	$ar \left\{\begin{matrix} achal' \\ at'' \\ alt' \end{matrix}\right.$	$ar \left\{\begin{matrix} al \\ al \\ al \end{matrix}\right.$ $ar \left\{\begin{matrix} at'' \\ alt' \end{matrix}\right.$

The empirical name *echet* is the second in a series of which *achet* (formic acid) is the first; *ichet* (propylic acid), the third; *ochet* (butylic acid), the fourth; *uchet* (amylic acid), the fifth; and so on to the highest or most condensed molecule *weuchet* (melissic acid), represented in the old notation by $HOC_{60}H_{59}O_3$, and in the new by $\mathbf{C}_{30}H_{60}\mathbf{O}_2$. These short and simple names, formed by changes in the first syllable, represent these acids as the result of successive additions of *ach* ($\mathbf{C}H_2$); but they cannot be made available in illustrating the changes which occur when an atom of hydrogen is replaced by metal or a radical. The other empirical name may be used by those who prefer to express no opinion as to the actual constitution of the acid. To carry out this view, the replaceable atom of hydrogen in the acid may form the first syllable, and the remaining syllables will be the terminal of the acetates formed by monad metals, *e. g.*, acetic acid, *alilert;* acetate of potash, *Kalmilert.* . The terminal syllables must be doubled in value, to denote acetates of dyad metals; for example, acetate of lead, *Plubmealort.* In consideration of the existence of numerous important bodies, into the construction of which an acid-forming radical of this series enters,

it has been found most desirable to designate the acids by names which bring the radical more clearly to view. Preference is therefore given to those which are readily resolved into the water or dyad type; thus, acetic acid, as *alartachalt* or *lartachalt*, is easily separated into syllables which reveal its typical structure [*al-artachal*]*at*. When *al* is replaced by a monad metal, the typical form is still apparent [*am-artachal*]*at*. An atom of a dyad metal replaces the hydrogen atom in two molecules of acid; therefore the torso *artachalt* is doubled, which is indicated by the suffix *e* having the sound of *eh*, thus, *artachalte*. In the sesqui-acetates, the double torso *artachalte* is trebled, and indicated by the suffix *ea* = 6; for example, the acetate of alumina = $Al_2C_{12}H_{18}O_{12}$, is *Alem-artachaltea*.

(To be continued.)

Bibliographical Notices.

The American Colleges and the American Public. By Professor Noah Porter, D. D., Yale College. New Haven, Conn.: Chatfield & Co., 1870.

The general inquisition to which the American collegiate system is now being subjected will insure to this book a careful perusal. Most of its chapters are the sum of long experience, and are very suggestive to all connected with our collegiate system. It is to be regretted, however, that wherever the author touches upon the, at present, unsettled points of the college curriculum, his enthusiasm, and genuine affection for the old course in which he was educated and has since labored, have led him into extravagancies of statement, which may impair the force of really valuable portions of the book, and sometimes have even rendered him dogmatic, and discourteous in use of epithets towards the advocates of the New Education, thus lowering the style, and suggesting to the minds of unbiassed investigators, conscious weakness, or inability to discuss the merits of the new, by reason of long and entire devotion to the old. There is space to notice but a few points.

The account of the rise and early abandonment of the plan of educational reform in many of our American colleges about thirty years ago, can scarcely be converted into an argument against it, especially in the face of the present more general and successful attempt. This reform, like all others in opposition to "what has been approved by the practice of many generations," may only vindicate its character as a reform, after many apparent failures. Might not failure, indeed, be expected in a reform which must necessarily at first encounter the prejudices, we might almost say self esteem, of the mass of educated men, as well as the almost sentimental attachment to the associations and formulæ of college days? With these men, for the most part, in charge of our educational institu-

tions, would it be singular if plans, perhaps reluctantly adopted, should not be the very best, or should not be cordially or intelligently executed, and that they should be hastily abandoned before thorough trial? It is well to ask whether many of our colleges now, are not yielding reluctantly to what they consider a popular clamor for change, and advertising a plan of education which they cannot or do not carry out at the risk of bringing disrepute upon the new movement?

Another very pertinent inquiry suggests itself in this connection. How far have colleges themselves been failures in the past thirty years? That is, how does the rate of increase of numbers graduated, compare with the rate of increase of population? Would the standard of education, taking the average or the highest point, be lower now had the educational reform of thirty years ago been adhered to? Would the number of classical scholars be much smaller, or their education more thorough? Might we not have in many practical walks a greater number of liberally educated men—men who would have taken the full college course of four years, with the simple substitution of German and French or Practical Scientific Studies for the Latin and Greek of the last two or three years? They, or their friends for them, in the exercise of their best judgment, have rejected the prolonged study of Latin and Greek, not as worthless, but as not worth the time and labor to be bestowed upon them. There seems to be a prevalent and persistent misconception, or ignoring of the aim of the advocates of the reform on the part of its assailants, as seen in the continual harping upon the words *utilitarian*, *practical*, &c., and the frequent appropriation of the word *severer* to designate the old course by the author, and the tenderness for the word scholarly, as something distinctive of it. The most influential advocates of the reform do not rest its claims solely, or for the major part, upon the low utilitarian grounds attributed to them, but on the higher utilitarian grounds of mental discipline. They do not fail to recognize the fact that disciplinary studies are valuable *per se*, but conscious for the most part, of a peculiar mental power acquired, and pleasure enjoyed, in the study of branches not properly represented in the college curriculum, they simply suggest that those who desire it, may be trained by the study of these branches instead of others. Many of them, as is admitted by the author, are college graduates of good standing—they have become by subsequent enlarged study in so far emancipated from the thraldom of college associations, and the reverence for what is old and established, simply because it is so—for a college community is a type of conservatism—that they simply ask that their sons be allowed to enjoy all the advantages incident to college life, from instruction and association, with the privilege of arranging those studies, about which there is a respectable difference of opinion, according to their own judgment. There is no proposition to lessen the amount or intensity of mental exercise. That the branches selected by them may have an immediately practical as well as dis-

ciplinary value, they do not consider objectionable or disgraceful; though indeed, at times, there really seems to be manifested in certain quarters a feeling of disgust for any branch of education that may in any way serve directly to answer the great questions, "what shall I eat, what shall I drink, and wherewithall shall I be clothed?" There is an air of intellectual snobishness in the restriction of the word *scholarly* to the immediately useless, just as there is in considering an approved gymnastic exercise a genteel, and the sawing of wood, or any other useful employment that would exercise the same muscles, a vulgar mode of exercise.

Again, would not the increase of students by the elective privilege lead to more general interest in the adoption of a collegiate education? Would not the number of classical students be increased? Could not able professors, with the presumption of long established approval in their favor, and the rich treasures of ancient lore, retain a hold on many young men, already through with the dry elementary study of Latin and Greek? Would not the students of the old curriculum also derive benefit from association with those pursuing, only more thoroughly and enthusiastically, certain studies, since most of the studies would remain common to all the students, and there would be so many points of contact in class-room society, hall, and social life?

Would not the influence of the development of the two kinds of education, side by side, exert a salutary influence upon the instructors? Even our author, after a full examination, is led to suggest a radical modification of the method of instruction in the ancient languages, resting upon a particular view of the utility of these branches of a liberal education to which we call attention subsequently.

In the discussion (Chap. II) of "The Studies of the American Colleges," the author seems unconsciously to write from the elevation of a professional student of the ancient languages and literature. Whilst most educators will be disposed to concede much that is claimed for the study of language as disciplinary, many will take exception to the various reasons suggested by the author, in reply to the following quotation from President White: "It is impossible to find a reason why a man should be made a Bachelor of Arts for good studies in Cicero and Tacitus, and Thucydides and Sophocles, which does not equally prove that he ought to have the same distinction for good studies in Montesquieu and Corneille, and Goethe and Schiller, and Dante and Shakspeare."

C. F. H.

(To be continued.)

Steiger's Literarischer Monatsbericht, (Literary Monthly Record), May, 1870. Pp. 72. 12mo. E. Steiger, New York.

Steiger's Monatsbericht, commenced May, 1869, the only literary periodical published in the German language in the United States,

enters upon its second volume, the first number of which has just been issued. Among its interesting contents will be found an article on the distinguished historian, *Friedrich Kapp*, who has just returned to Europe after twenty years' sojourn in this country, and whose works, some of which have been translated, are widely known,—an inquiry, "*Which is the first German book printed in America?*"—"*The Poppenhusen Institute*" *in College Point*, an institution generously founded and endowed by a German, for the advancement of knowledge and the improvement of the moral and social condition of the working classes, an account of the *Growth of the Book and News Trade in the United States*, with special reference to H. H. Bancroft & Co. and Sinclair Tousey,—besides many minor notes connected with Schools, and other matters of value to all literary men. We notice also the prospectus of a List to be compiled of all who have written German Books and Pamphlets in the United States; but the most striking feature of the present number of the *Literary Monthly Record*, is the announcement of a *Prize of Eight Hundred Dollars* offered for the best *Historical Sketch of the intellectual vigor and progress of the German Population in North America*, more particularly exhibiting *the influence of the German-American Press on the development of American Institutions.* Further particulars can be had in the periodical itself which may be obtained free by addressing *Steiger's Literarischer Monatsbericht*, 22 and 24 Frankfort Street, New York. It should be added here that the publisher continues to send his *Monatsbericht* free and prepaid to all who wish to have it.

As Regards Protoplasm, in Relation to Prof. Huxley's Essay on the Physical Basis of Life. By James Hutchison Stirling, F.R.C.S., LL.D., Edin. New Haven: Chas. C. Chatfield & Co.

An unpretending little book, but one which we cannot too highly admire for the polemical skill and logical acumen displayed by its writer, who is a master of the perplexing theories and still more perplexing details of the most difficult portion of organic science.

Chemical History of Six Days of Creation. By John Phin. American News Company. New York. 1870.

A very readable book, containing, in condensed form, about all the information on the subject which could be placed in comprensible language before the reading public; besides quite an amount of general scientific information incidentally presented throughout. It deserves to be well received by the class for which it was designed. Quite a number of the comparisons instituted are new to us, and though we find here and there occasion to differ from the author, his views have a freshness all the more agreeable in a field so well filled with stereotyped literature.

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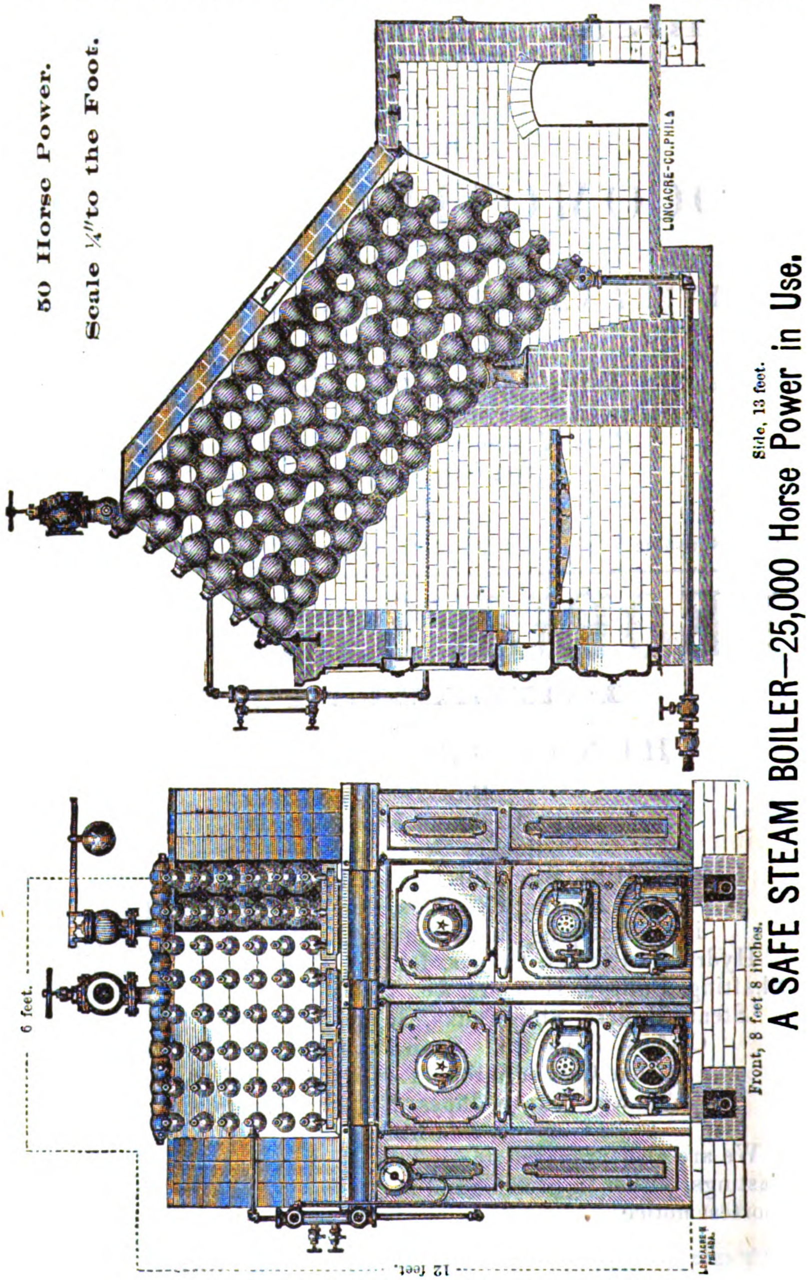

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EDITORIAL.

ITEMS AND NOVELTIES

Lime-Lights in the Caisson of the East River Bridge.—On page 32 of this volume we alluded to the fact that arrangements had been made with the New York Oxygen Gas Co., to supply gas for a series of lime-lights by which the six compartments of this huge caisson might be lit.

We can now from personal inspection describe the arrangements by which some 14 of these lights are kept in constant and successful operation. The plan of these adjustments is, we understand, chiefly due to Mr. Martin, Assistant Engineer. To secure a steady supply of each gas under constant pressure, two large sheet iron cylinders, about 21 inches in diameter and 6 feet high, are placed upon the top of the caisson and are connected by iron piping with a water reservoir on the roof of an adjacent building, by which means a hydrostatic column or pressure of some 16 pounds per square inch

is made available. These cylinders being first filled with water, the gas is let into them from the portable cylinders supplied by the Oxygen Co., in which it is compressed up to a pressure of 225 pounds to the square inch. This displaces the water, forcing it back into the elevated tank and leaving only the tension due to its hydrostatic column of 32 feet.

Glass gauges exactly like those used on steam boilers show the level of the water in the stationary cylinders, and thus enable the attendant to regulate the supply of gas in these, so as neither to overcharge them (when the excess would escape through the water pipes and tank) nor allow them to become empty.

From the upper part of the gas reservoirs or stationary cylinders just described, service pipes are carried down into the caisson, and there distribute to the outer ends and middle points of each chamber where the usual jets and lime holders are permanently attached.

The light afforded by this means is excellent, and if it is possible (as we imagine it must be) to whiten the roof and upper part of the caisson walls, its efficiency would be very largely increased. In looking from one chamber of the caisson into another, where one of the lights was near the doorway but out of view, we were strongly impressed with the idea that daylight was entering through some unexpected opening. The foggy state of the air causes a considerable loss of light, so that at a distance from the burner this is less effective than one might expect. With the number of lights now in use, however, the supply is sufficient, and candles are only required in a few locations sheltered from the direct rays. We feel sure that a whitening of the roof and walls would be of very great service.

It is proposed to let the gas reservoirs descend as the caisson goes down, building around them a coffer-dam, by which means the hydrostatic head will be increased exactly as the air pressure in the chambers is raised, so that a constant difference will be maintained.

The greatest depth to be reached being 40 feet, the maximum pressure required, according to the present standard, would be about 36 pounds, and the pressure in the small charged cylinders being 225 pounds, no difficulty will be found in introducing the gas from them. The pressure now used is, however, largely in excess of what is required, as one or two pounds above that in the caisson would be quite sufficient to secure the steady burning of

the lights. In fact, we are sure from previous experience that the pressure between the stop-cocks of the jets and the flames, is now not more than a small fraction of a pound per square inch in excess of the surrounding compressed air. Were there any object in reducing it, we are quite confident that 25 pounds above the atmosphere would be an abundant pressure at the maximum depth of 40 feet.

The amount of gas now consumed is about 1200 cubic feet of each kind per day.

The East River Bridge.—Sinking the caisson for the Brooklyn pier.—In the fifty-fourth volume of this *Journal*, at page 243, and again at page 305, was published a full preliminary report on this bridge. Since then we have from time to time kept our readers informed of the progress made in this work, (see brief notes, Vol. LV., page 367, Vol. LVIII., page 147 and 220.) Account of preliminary negotiations and structure of caisson for the Brooklyn pier, Vol. LVIII., page 361. Preparatory submarine blasting and launch of caisson, Vol. LIX., page 223. We can now add from personal inspection a few words on the methods and progress of the work which is now going on in the process of sinking the first caisson. In company with Mr. A. P. Boller, C. E., we called upon Mr. F. Collingwood, Asst. Supt. at the bridge office on Fulton street, and were by him kindly convoyed through the works which it was our wish to inspect. Our first visit was paid to the compressors, six in number, built by the Burleigh Rock Drill Co., Fitchburgh, Mass., each one capable of delivering 90 to 120 cubic feet of air per minute as measured at the ordinary density.

Three only of these are now in general use, the others standing ready at a moment's notice, though occasionally in a very rapid fall of tide four and even five have been employed.

A jet or spray of water enters each compressing cylinder constantly to cool the air, which is heated by the compression, and by means of a large drum, and appropriately arranged drips, the water so introduced is removed. From this drum an air main, 10 inches in diameter, passes on toward the caisson branching into two 8-inch pipes each provided with a safety-valve, and from these, rubber tubes 6 inches in diameter carry the air to the air-shafts of the caisson.

One of the compressors is used to condense the street gas, for use with the oxygen employed for lighting the interior of the caisson, as we have fully described in another place, and also occasion-

ally to operate an air syphon pump (similar to the steam syphon pump) under the caisson.

From the compressors and their attachments we then proceeded to the top of the caisson, which, with its huge blocks of masonry derricks and iron work, gives more the idea of a massive foundation already perfected than of a sort of loaded diving bell as it really is. Its size, it will be remembered, is 168 feet by 102.

Two dredging machines, somewhat after the oyster-rake pattern, operate in the two water shafts which are simply rectangular tubes about 6 feet square, running below the bottom level of the caisson and filled with water to the level of the river outside.

By temporarily closing them above and forcing air in, the water is expelled, and excavation can be carried on beneath them, so that a sort of pool or pocket is made into which (after re-admitting the water) the excavated material is thrown and elevated by the dredges.

The rakes or scoops of the dredges are raised and lowered by wire ropes winding on to drums connected with independent engines by conical friction wheels or clutches.

The movement of the dredges is thus controlled by a combined manipulation of the friction clutch and throttle-valve of the steam engine.

It has been found that by raising the large blocks of stone by one dredge, and the mud by the other, the work was greatly facilitated, the material to be removed being a mixture of boulders and mud, which quickly packed together again so as to resist the action of the dredge if thrown into the same pocket.

By means of one of the air-locks (which in this case are at the top of the shafts, though in the new caisson for the New York pier they will be at the bottom), we then descended into the chambers of the caisson. The effect on the ears, of admitting the compressed air, was very notable in our experience, but the painful sensation was promptly relieved by puffing out the cheeks with air, so as to equalize the pressure by introducing air behind the drum of the ear through the Eustachian tube.

On reaching the scene of action on the river bottom below, we found ourselves in a series of vast iron roofed vaults, illuminated by a goodly number of lime lights which but for the black color of the walls and roof, and the hazy nature of the air would have made the whole interior as bright as a ball room. As it was, no difficulty was experienced in distinguishing objects even at the points most

distant from the lights, and near them of course the effect was an approach to that of daylight.

Occasionally, a candle was used where a boulder was being attacked under the edge of the caisson or its partitions, and consequently out of the line of direct rays.

A whitening of the walls and roof will, we are sure, be of the greatest advantage, and in cold weather, when the air introduced will probably deposit more of its moisture in the supply tubes the difficulty of the misty air will no doubt be alleviated.

Owing to the exceedingly unfavorable character of the ground encountered (the site as it will be remembered, see page 361, Vol. LVIII., being unaffected by dredging until it had been loosened by submarine blasting) and the relative inexperience of workmen, not to mention other impediments which could not have been anticipated before they were encountered; the progress thus far has been very slow, but many changes leading to an increase in the rate of advance have been already made, and others will, beyond doubt, be speedily effected, and as all previous experience has shown, the rate will increase progressively as the work advances.

St. Louis Bridge.—The following is a brief statement of the condition of the work upon the bridge at St. Louis, according to the latest advices from its constructor, Jas. B. Eads, C. E.

The masonry of the west abutment is about 14 feet above the present stage of the river. The western pier is about 16 feet, and the eastern pier about 4 feet above water. The laying of the masonry is progressing on the west abutment and on the east pier. The granite (from Portland, Me.,) for the west pier is on its way up the river. Some 50 or 60 vessels laden with granite for the work are now upon the ocean, and two cargoes are on their way up the Mississippi from New Orleans. No further delay is therefore anticipated on account of material for masonry. The caisson for the eastern abutment is nearly finished at Carondolot, six miles below the city, and will be launched and placed in position in about two weeks. This abutment will be sunk to the bed rock, 136 feet below extreme high water mark, and will consequently penetrate eight feet deeper than the pier which was put down last winter.

These four masses of masonry constitute the foundations for the bridge proper, those for three of the smaller piers in the western approach have already been put in, the deepest one extending 21 feet below the city directrix. This one has been recently put down, and is nearly completed to the wharf level.

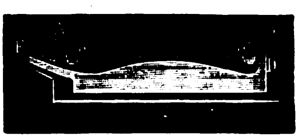
Cause of the Fires of Pine Forests.—F. Schrader.—In a late number of *Cosmos* occurs an interesting paper upon the cause of the frequent fires of pine forests.

In France, in some of the Departments, as well as with us, where this phenomenon is of almost constant occurrence during the summer weather, it has been heretofore the generally accepted explanation, that they were due to willful arson, or to accidental imprudence.

The author offers us another explanation, which is, to say the least, highly ingenious. He asserts that the hollow globes of resin, which exude abundantly from these trees, act as so many burning lenses to concentrate the heat of the sun's rays, in this way causing the combustion to begin, and once started, to spread rapidly in consequence of the highly inflammable nature of the materials (resins and turpentine) contained in the wood.

Artificial Horizon.—An improved form, by J. H. Lane.—At the Troy meeting of the American Association, Mr. Hilgard exhibited this very ingenious arrangement by which the vibration or ripple which acts so annoyingly under many circumstances with the ordinary tank of mercury, is effectively suppressed.

A B is a shallow dish with a circular groove *ee′* around its edge, and a cavity, C, beneath, which communicates with the groove by the space D, while by means of a tube, F, air may be blown at will into the cavity C. This cavity and the circular groove are filled with mercury.



By blowing into the cavity, more mercury is raised and overflows into the central portion of the dish. On now allowing the air to escape and the excess of mercury to flow back into the cavity, a film, held by its cohesive force, is retained over the surface between *e* and *e′*, and by reason of its thinness, this is incapable of maintaining a vibratory or ripple movement. A touch with the finger will instantly break up this surface, but it is easily reformed, and experience has shown that it is not deflected from its horizontal direction by slight inclination of the dish.

The New Cambridge Transit Instrument.—During a late visit to Cambridge, we had the pleasure of examining the above-named piece of apparatus, which has just been added to the appliances of this observatory, and which contains many novelties of

construction and arrangement (due to the invention of Prof. Winlock) worthy of special notice, and without doubt generally interesting to our readers.

In the first place, with reference to its mounting.

The pivots are not supported in Y's, but on account of the great weight of the instrument, as well as for other reasons developed by experience, have journals accurately fitted to them. These journals, in their turn, are not provided with means of adjustment, but are permanently attached to plates set in the piers, and brought by scraping and repeated trials, to the exact surface required for an accurate adjustment of the instrument once for all.

Another novelty consists in the arrangement of the setting levels and circles at the eye end, which are turned by a gear wheel, in place of the clamp and tangent screw, which is so apt to "run out" at a critical moment. The new movement is extremely smooth, gradual and convenient, being always ready, and never "running out."

Again, the screw controlling the horizontal wire of the micrometer in the eye-piece, beside having the graduations for parts of a turn clearly marked on the sides of its cylindrical head, in such a way that they can be easily read, has a similar graduated head connected with it by gearing, which records the whole number of turns in a like manner.

The collimating lenses used with this instrument are of unusual size, being in all respects similar to the objective, which is of eight inch aperture, and we should judge about 8 or 9 feet focal length.

Other novelties have been introduced by Prof. Winlock in the reversing carriage, by which the time required for reversal is reduced to a few minutes in place of several hours. This instrument was made by Troughton & Sims.

Photographic Record of Solar Changes.—Since the beginning of the present year, Prof. Winlock, of Harvard, has been making, by a new method which is equally remarkable for its simplicity and effectiveness, a series of sun pictures, in which spots and faculæ are depicted with a precision which has been rarely if ever equalled.

The primary objects in this work have been to prepare and perfect apparatus and processes which might be used with the best results during the coming transit of Venus, in 1874, but indirectly a series of records has been obtained which will be of incalculable

service in the study of the physical condition of the sun. The plan pursued is as follows: A tin tube, some 40 feet in length, is supported in a horizontal position about north and south, and carries at its north end a lens of 6 inches aperture and 40 feet focal length. The other end of the tube enters a small house which serves as a photographic dark-room, and is there provided with the usual adjustable plate holder employed in an ordinary camera. At a short distance in front of the lens, or north end of the tube, is set a plate of unsilvered glass, slightly wedge shape to avoid the reflection from the second surface, so mounted as to follow the sun, and throw the reflection constantly on the lens.

The image of the sun on the sensitive plate is about 4 inches in diameter, and so greatly are all errors of the lens reduced by the long focus and small aperture of 2½ inches, that with a common uncorrected glass the most admirable pictures have been obtained. The exposure is regulated by dropping a diaphragm-slide outside of the lens.

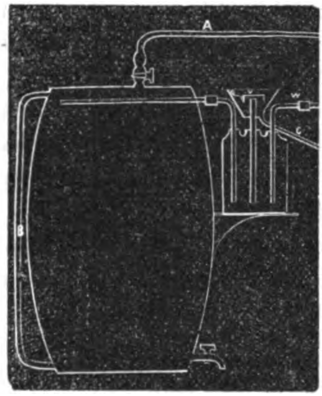
The Hydrogenium Amalgam of Loew; concerning which, incidental mention was made in the last number of the *Journal*, is prepared as follows:

An amalgam containing from 1 to 4 per cent. of zinc is made, and this shaken vigorously with a solution of chloride of platinum, (containing about 10 per cent. of the solid chloride). The liquid becomes colored, and soon a dark powder is thrown down. If, to the contents of the vessel, at this stage, dilute hydrochloric acid is added, the mass swells in bulk, and a substance having the consistency of butter, and a bright metallic surface is obtained. This, according to the discoverer, is a true amalgam of mercury and hydrogenium. In its physical properties it bears great resemblance to the well known ammonium amalgam. Like this, too, it is very unstable; and rapidly decomposes, with the evolution of hydrogen, diminishing steadily in bulk until nothing but the metallic mercury is left.

On a Steady Air Blast for Laboratory Purposes.—By Prof. Le Roy C. Cooley, Ph.D.—In the use of the blow-pipe, and for many other purposes in the laboratory, it is desirable to have some automatic source of air. An apparatus for this purpose ought to furnish a *steady* current under *pressure* which may be *varied* and *controlled* by the operator.

A simple and inexpensive arrangement, fulfilling these condi-

tions, has been in almost daily use in my laboratory for nearly three years. Although devised especially for use with the blow-pipe, yet its applications are so numerous and varied that it may be recommended as a valuable piece of furniture for both the laboratory and the lecture-room.



The essential parts of the apparatus are an air-tight tank from which air is to be driven, and a regulator by which the current is to be made uniform and its force determined.

The tank may be made of metal or of wood, and of any size and shape desirable. A wine-cask or beer-barrel answers the purpose admirably. The water, by which pressure is to be obtained, must enter the side of the tank *near the top;* the pipe which supplies it extends almost to the opposite side of the tank, in order to avoid the unpleasant rattle of falling water. A glass tube, B, extending along the height of the tank, both ends opening into the interior, continually announces the height of water, and informs the operator of the amount of air at his disposal. Besides these tubes, the tank is supplied, at the top, with a stop-cock and tube, A, by which the air blast is delivered, and at the bottom with a large faucet, by which the tank may be quickly emptied. The arrangement of this tank, except in one noticeable feature, does not essentially differ from others already well known.

The regulator, by which the pressure is steadied and controlled, is peculiar and efficient. It consists of a small-sized vessel with three openings in the top, each supplied with a tube which reaches nearly to the bottom of the vessel. One of these tubes, W, receives water from the hydrant, another delivers it into the tank, while the third carries the valve which regulates the pressure. The water entering the vessel through the first tube until it covers their lower ends, will, of course, be driven up the other two with equal pressure, and their upper ends being on the same level, it will issue from both always with equal force. Let the valve-tube be covered closely, and the pressure needed to lift the cover will be the pressure exerted to push the water into the tank, and will also

represent the force of the issuing air-jet. The cover or valve, V, is simply a small tin cup, with its bottom lined with rubber, inverted over the smooth open end of the tube. It is fastened to an arm hinged upon some permanent part of the apparatus, by which free vertical motion is secured, and any other prevented. Upon the flat top of this valve, weights of any denomination may be placed, and the force of the blast correspondingly increased, limited only by the power of the stream from the hydrant. The principle known as the pneumatic paradox prevents the pressure from being accurately *measured* by the weight of the valve; but, in practice, this is found to be of no importance, since it does not hinder the quick adjustment of the pressure by varying the weights. The valve-tube should be considerably larger than the supply-pipe, that the relief may the more easily adjust itself to the supply. Its upper end should pass through the bottom of a vessel by which the water may be caught, and from which it may be carried off by a tube, C, into the cistern.

With this arrangement it is found, that however variable the pressure of water from the hydrant, the steadiness of the air current, after the first few moments, is not affected, and that however powerful may be the stream of water, the force of the blast will be delicate or strong, according to the weight of the valve.

Any form of blow-pipe may be used with this apparatus, but the Bunsen's blow-pipe will be found most advantageous, not only for the ordinary purposes of the instrument, but also for many others. As a source of long-continued, steady heat, this arrangement is unequalled. It will work for hours with the most gentle flame, or may be made to operate with the fury of a blast-lamp, at will.

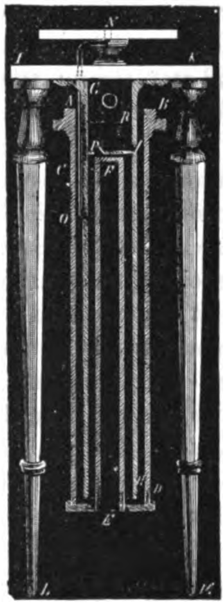
Of the numerous applications of this cheap and simple apparatus, no more need now be said. One, however, which seems to be new and interesting, and which may prove to be of much value, must be the subject of a future communication.

Automatic Mercurial Pump.—By Prof. C. A. Young, Ph.D.—We use the name automatic in this instance loosely, as indicating that the valves are self-acting, and do not require attention at each stroke, as in the apparatus of Geissler and its congeners.

So much being premised, we will endeavor to give an account of the instrument described to us recently by Prof. Young.

A B is a strong iron or steel ring, with gudgeons for its support, into which is screwed an iron tube C D, connected by means of a ring

E at its lower end with another tube E F, which is closed at its upper extremity. This is the movable part of the pump, and being supported by the gudgeons A and B at one end of a balanced lever by means of links, may be raised and lowered through a stroke of about 10 inches.



Within the annular space inclosed between the tubes A D and E F, is another tube G H, supported by means of a strong collar at its upper end from the frame I K L M. A small tube N O passes from the centre of the pump-plate N to a point O in the cylinder about 8 inches below P.

At P is an air-tight diaphragm, with an upward opening valve, while in the side of the cylinder, to the right of P, is a valve opening outward. Another diaphragm, with a free opening, is found at R, and a hole near G gives an exit to the outer air.

A sufficient quantity of mercury being placed in the annular vessel and upon the diaphragm P, on lowering the movable portion, the level of the mercury in A D outside of G H, sinks, on account of the space left between F and R, and the partial withdrawal of G H, to, say, 30 inches below the level, inside G H, after which both levels fall together, leaving an absolute vacuum in G H between P and F.

Into this vacuum air will flow through the tube N O, from the vessel to be exhausted, the quantity of mercury and proportion of parts being so adjusted that the orifice O will be entirely uncovered at the end of the down stroke.

On raising the part A D, the first effect will be to elevate the level of the mercury between G H and F E, so as to close the outlet O of the tube N O. Then the air which has entered between P and F will be expelled through valve P, by the rising part F E, and the mercury around it, until at last even a little of the latter will be forced through the valve P , by the superior level in A D outside of G H. The quantity thus transferred will, at the succeeding down stroke, flow back through the valve in the side of G H, opposite to P. The diaphragm R is simply intended to prevent spattering of the mercury covering the valve P, as the escaping air flows through it.

CHEMICAL ITEMS.—Chromic Acid.*—The brown-red precipitate, which a solution of K_2CrO_4 forms with one of $AgNO_3$, exhibits a very different appearance, acccording as a considerable excess of silver or chromium solution is employed, and it is desirable to know whether the precipitates have still other differences. When a dilute solution of K_2CrO_4 is dropped into a concentrated solution of $AgNO_3$, a brown-red precipitate is formed: contrawise, no precipitate at first, but later, on addition of more silver solution, a voluminous orange-red precipitate. Both precipitates, decomposed HCl, and after separation of AgCl, the Cr precipitated by H_3N, gave the per centage composition of neutral argentic chromate Ag_2CrO_4.

When a concentrated solution of K_2CrO_4 was boiled for a long time with Ag_2O, and the residue washed with water, until the wash-water was colorless, a crystalline greyish-black powder remained. This, analyzed as above, proved to be a mixture of Ag_2CrO_4 with Ag_2O, and not a basic argentic chromate, as had been anticipated. $K_2Cr_2O_7$ yielded with Ag_2O, on similar treatment, a cherry-red powder having, according to analysis, the composition of the neutral argentic chromate.

A dilute solution of $K_2Cr_2O_7$ dropped into a concentrated solution of $AgNO_3$ yielded a red-brown precipitate; contrawise, no precipitate until addition of more silver solution. Both precipitate were argentic dichromate, $Ag_2Cr_2O_7$. The latter crystallized out of both its hot and cold solutions in nitric acid, gave small crystalline plates; from its watery solution, contained in an exsiccator, shining dark red crystals, which were large enough to confirm the determination already made by Teschemacher of their triclinic form.

The neutral mercurous chromate is most surely obtained by the addition of potassic dichromate to mercurous nitrate. When the latter is in excess the filtrate is colorless, and remains so during washing with cold water. The crystalline orange-red precipitate, dissolved in nitrohydrochloric acid containing an excess of HCl, the mercury precipitated by H_2S, and the chromium by H_3N, gave the p. c. composition of neutral mercurous chromate, Hg_2CrO_4.

If, on the contrary, a solution of K_2CrO_4 is added to a saturated solution of $Hg_2N_2O_6$, the precipitate at first is colorless, but on washing with cold water becomes colored, and the precipitate at the same time darker and basic. To hinder this, Berzelius employed a solution of $Hg_2N_2O_6$: very dilute Nitric Acid, according to Hr.

* C. Freese, Ann. der Phys. und Chem., 1870, No. 5, p. 76.

Freese is also a good washing fluid. When thus washed, the above precipitate yielded the p. c. composition of neutral mercurous chromate; washed with water the per centage of Cr was diminished, and instead of an atomic ratio of 1[Hg_2] : 1 Cr. as in the neutral chromate, the atomic rate 11 [Hg_2] : 10 Cr was obtained. It is probable that the $\frac{3}{4}$ mercurous chromate mentioned in Gmelin's Lehrb., is but one of the undefined basic salts, that result from the washing of the precipitated neutral chromate with water.

Analyses of the precipitates obtained on adding solutions of K_2CrO_4 and $K_2Cr_2O_7$ to HgN_2O_6, both yielded the per centage composition of trimercuric chromate, Hg_3CrO_6. No green crystals, as had previously been found by Kopp and Dröge, resulted from an evaporation of a solution of H_2CuO_2 or $Cu_2H_2CO_4$ in CrO_3. But the brown solution thus obtained, in an exsiccator, yielded warty masses only, which deliquesced in the air, and finally dried to a hard crust. There remained, on treating this mass with water, a residue of basic cupric chromate. It may therefore be assumed that the neutral cupric chromate can exist only in solution, and on evaporation is decomposed into an insoluble basic and an uncrystallizable cupric sesqui or dichromate.

In older works basic cupric chromates are spoken of as precipitates of a green color. According to the author such chromates do not exist, and the green color is due to some basic sulphate or cupric hydrate. Neither has the author obtained the tetracupric chromate, $Cu_4CrO_7 + 5Aq$ of Malaguti and Sarzeau. By very diverse methods he obtained in every case, tricupric chromate $Cu_3CrO_6 + 2\ Aq$. It results from dropping Cu SO_4 solution in concentrated boiling K_2CrO_4. It is only when the boiling solution of K_2CrO_4 is in considerable excess that the precipitate is free from sulphate. A. R. L.

Chemical Examination of American Grapes and Wines.—The following is an abstract from an excellent paper, by Prof. Chas. M. Wetherill, on the comparative value of American wines, as indicated by extended analyses of the same. The paper in question appears in a late number of the *Journal of Agriculture*. After a brief historical sketch the author remarks:—

The American vintner has to solve the problem: "to furnish from our native grapes a wine at as low a cost, and with at least as fine a flavor, as the well-known brands of Europe. The solution is difficult. Our climate will not permit the European vine to

flourish, unless in California, and the juice of our native grapes contains too much acid and too little sugar to afford a good wine.

When we reflect how ancient is the art of wine making on the old continent, and how much is to be learned respecting the capabilities of grapes in the New World, and, above all, how much has been actually accomplished in so short a time in America, we have great reason to be encouraged, and to persevere until we have attained success.

The localities of the grapes analyzed are stated in the following table of results. The first column of numbers denotes the percentage of juice in the grape. The results were obtained by weighing a quantity of the fruit, pressing it in muslin under a hydraulic press of the power of 6 tons, and weighing the residue. The juice was then filtered and its specific gravity was taken (col 2). Column 3 gives the percentage of ash of five specimens. of juice.

The fourth column embodies the important results of the analysis, viz., the percentage of dry grape sugar in the juice. The laws of chemistry teaches us that 92 parts of alcohol may be obtained from 180 parts of grape sugar; or, as we may say, for every per cent. of sugar in the juice ½ per cent. of alcohol is possible. A must containing 12 per cent. of grape sugar can not possibly give a wine containing more than 6 per cent. of alcohol, unless sugar has been added, or the must concentrated by evaporation.

The last column is no less important, although the results are only for nine specimens. It concerns the percentage of acid in the grape juice.

An examination of the table will show the value of the grapes in per centage of juice, richness in sugar and freedom from acid. With respect to the amount of juice, there is not a very great difference between the respective specimens; the lowest is No. 5, the highest is No. 14; the average of 16 specimens is 79·11 per cent. of juice in the grape. Dr. Jackson, in 1859, gives an average per centage of juice, in 38 specimens of native grapes, of 67·23.

Comparing these with the results which we have for foreign grapes, we find that Berthier determined the per centage of juice in Chasselas and Pineau, grown in the neighborhood of Paris, at 73·81 and 72·43, respectively, or, mean, 73·12. The mean of Dr. Jackson's and of my results is 73·17, which is almost exactly the mean of Berthier's analyses. The amount of juice, therefore, of American grapes is not different from that of the European fruit.

Chemical Analyses of Grape.

No.	NAME OF GRAPE.	Approximate per centage of juice in the grape.	Specific gravity of the juice.	Per centage of ash in the juice.	Per centage of dry grape sugar in the juice, by Fehling's test.	Per centage of acid above neutrality in the juice, calculated as dry tartaric acid.
1	Raabe	79·70	1·079	0·84	15·87	0 926
2	Baldwin Le Noir	82·67	1·107	0·49	20·56	0·933
3	Rebecca	80·82	1·088	(*)	11·63	0·514
4	Deveraux	73·19	1 096	0·78	11·55	0·803
5	Canby's August	70·48	1·082	(*)	11·70	(*)
6	Black September	72·60	1·057	0·80	8·95	1 754
7	Clinton	76 08	1·096	0·61	17·07	1·022
8	To Kalon	79·62	1·077	(*)	12·63	0·817
9	Cuepern	85·88	1·079	(*)	14·12	(*)
10	Cape	78·90	1·065	(*)	10·45	(*)
11	Norton's Early Virginia	77 62	1·089	(*)	15·90	(*)
12	Diana	74·82	1·085	(*)	14·87	(*)
13	Union Village	86·26	1·043	(*)	7·73	(*)
14	Montgomery	88 06	1·047	(*)	8·40	(*)
15	Cassidy	Too few grapes to determine.	1·087	(*)	15·41	(*)
16	Herbemont		1·080	(*)	16·73	(*)
17	Delaware		1·077	(*)	18·41	(*)
18	Marion		1·071	(*)	13·25	(*)
19	Trimon		1·055	(*)	9 57	(*)
20	Ontario		1·048	(*)	8·35	(*)
21	Elsinburg		1·062	(*)	10·76	(*)
22	Anna		1·078	(*)	11·98	(*)
23	Schuylkill	77·64	1·069	(*)	14·60	0 811
24	Bland	81·60	1·072	(*)	14·94	0·838

It is very different with respect to the sugar which gives the alcoholic value to the grape. The average per centage of sugar found by me is 12·5; the mean of Dr. Jackson's analyses is 11·6 per cent., or for our examinations combined, a mean of 12 per cent., which could not give a wine of greater than 6 per cent. of alcoholic strength. The sugar in the several grapes of the present research, varies from 7·73 to 20·36 per cent. I found a larger amount of sugar in the upper than in the lower half of the same bunch of No. 14. The European wine grapes give a much larger amount of sugar than those which I have analyzed, as may be seen by the following table from Mulder:—

This is equivalent to a general mean of 19·5 per cent. of sugar for all of the grapes analyzed. We have, therefore, to improve our grapes to the extent of 7 per cent. in sugar before we can make

(*) Not determined.

a wine of the same average strength of the European wines. The result is deduced from the consideration of all the grapes analyzed. If we take certain varieties we will need to improve their sugar to a less degree; thus the Delaware No. 17 is already a good wine grape, and No. 2, Baldwin Le Noir, contains an amount of sugar equal to that of Europen grapes, at least in the specimens analyzed by me, and grown by the Agricultural Department. The grape No. 9 is a foreign specimen, having been imported from Sans Souci, near Berlin, by Mr. C. J. Uhlmann, in 1860.

Analyst.	Locality.	Per cent. of Sugar.
Chaptal	Banks Cher and Loire	15 to 20
Fontenelle	South of France	18 to 30
Guentzler	Stuttgard	15 to 22
Ruess	Stuttgard	13 to 25
Schnebler and Koehler	Neckar	14 to 24
Klubeck	Styria	17 to 26
Metzger	Heidelberg	14 to 22
Balling	Bohemia	14 to 23
Mean of all		15 to 24

The Acid.—Th amount of acid in the grape juice determines the acidity of the wine; so far as it is not masked by sugar remaining unfermented. Fresenius and others have given analyses of grape juice in which the tartaric acid varies from 0·56 to 1·11 per cent.; the acid being present as bi-tartrate of potash. The celebrated Johannisberg grape, of the vintage of 1860, contained 0·74 of tartaric acid, and not more than 19·2 per cent. of sugar, although the same chemist found in the grapes of the Rhinegau from 24 to 28 per cent. of sacchrine matter.

The results of my examination of American grapes give from 0·80 to 1·75 per cent. of free acid. This is considerably greater than in the analyses above quoted, in which only half the tartaric acid given, is free to exert its acid reaction, the remainder being masked by its combination with the potash. Taking both sugar and acid in question, as well as the amount of juice yielded, the specimen, No. 2, is found to be the best wine grape of those analyzed by me. It remains for a full examination to show in what respect this opinion may have to be modified. I regret not to have had the opportunity of analyzing, at this time, specimens of the Concord and Catawba grapes.

Editorial Correspondence.

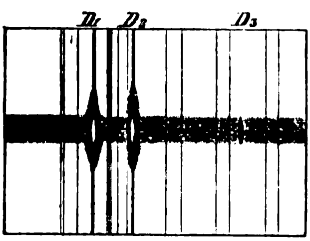
The following interesting communications from Prof. C. A. Young were received too late for a regular introduction in this number, but the Editors deemed them so important that they have introduced them without delay, as supplemental sheets.

DARTMOUTH COLLEGE, HANOVER, N.H., *Sept.* 26, 1870.

Prof. Henry Morton, Ph.D.

DEAR SIR :—

I write to inform you that last Thursday, Sept. 22d, about 11 A.M. Hanover mean time, I was so fortunate as to see the sodium lines D_1 and D_2 reversed in the spectrum of the umbra of a large spot near the eastern limb of the sun. At the same time the C. and F. lines were also reversed, but with the great dispersive power of my new spectroscope I see this so often in the solar spots, that it has ceased to be remarkable.



The figure gives the appearance of the sodium lines. In the umbra of the spot the D_3 line was not visible, but in the penumbra was plainly seen, as a dark shade, represented in the figure.

I am not aware that this reversal of the sodium lines in a spot spectrum has ever been observed before; its reversal in the spectra of prominences is not very unusual. A small prominence on the western limb of the sun, which was visible the same forenoon, presented all the following bright lines, viz: C, D_1, D_2, D_3, 1474·, b_1, b_2, b_4, 1989·5, 2001·5, 2031·, F, 2581·5, 2796·, and *h*; 15 in all.

In the spot spectrum the magnesium lines b_1, b_2 and b_4 were not reversed, but while the shade which accompanies the lines was perceptibly widened, the central black line itself was thinned and lightened. Yours, &c., C. A. YOUNG.

DARTMOUTH COLLEGE, HANOVER, N. H., Sept. 28, 1870.

Prof. Henry Morton, Ph.D.

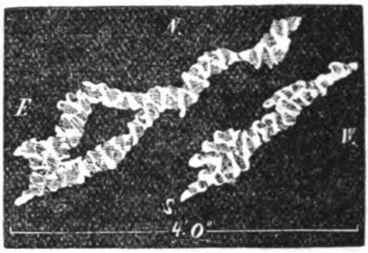
DEAR SIR :—

I write to tell you that this afternoon, with the help of Mr. H. O. Bly, our photographer, who has assisted me in the matter with great skill and interest, I have succeeded in obtaining photographs of protuberances on the sun's limb, of which I enclose a specimen. They

were obtained by attaching a small camera to the eye-piece of the telescope and opening the slit somewhat widely. We worked through the Hydrogen line near G.

As a picture, the little thing amounts to nothing, because the unsteadiness of the air and the maladjustment of the polar axis of the equatorial caused the image to shift its place slightly during the long exposure of three and a half minutes which was required, thus destroying all the details. Still, the double headed form of the prominence is evident, and the possibility of taking such photographs is established.

Success will depend upon the use of more sensitive chemicals (those used to-day were the same ordinarily employed for portraits,) and a very careful adjustment of the equatorial axes and the clock work. I fear a telescope of much larger aperture than mine will also be found necessary, in order to produce pictures that will really give much of an idea of the form and texture of these beautiful clouds.

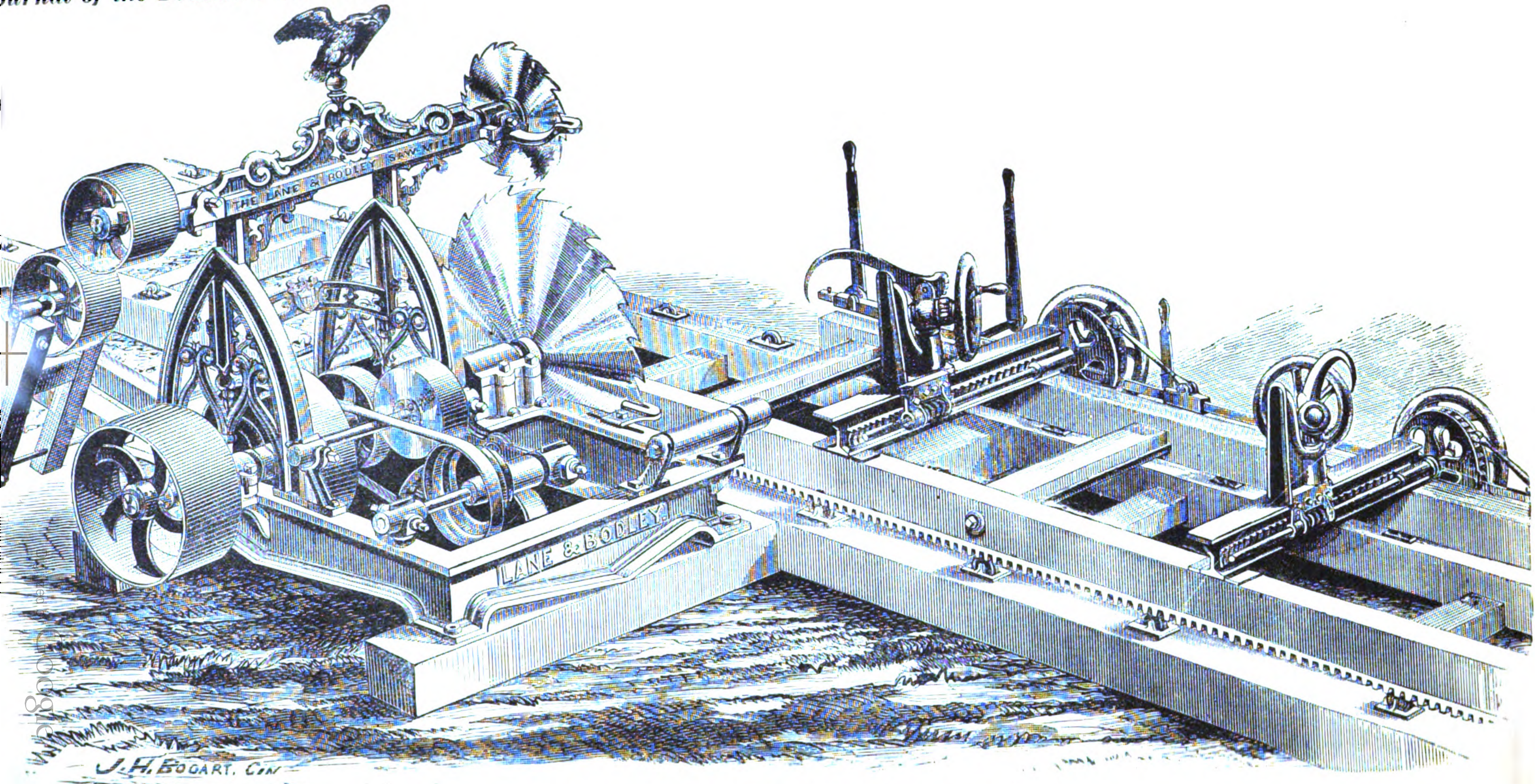


I may add, that between 3·50 and 4·30 o'clock this afternoon the umbra of the spot upon which I made the observation of the sodium lines, as communicated to you a few days ago, reversed the following lines (ranged in order of brightness), viz: C. F. D_3 2796 K (Hyd.γ), b_3, b_1, b_2; D_1, D_2, h, b_4, and 1474 K.

The brightness of b_3 was remarkable. Another spot, just south of this nucleus (which was the most southern of four in the same penumbra), also reversed the Hydrogen lines very finely, and on opening the slit a little, it was found that the phenomenon was caused by two enormous protuberances or luminous clouds, which in the spectroscope shone brightly even upon the surface of the sun.

Their form could be distinctly traced—at 4·05 it was as given below: the right hand one terminated in, or close to, the nucleus of the spot; the other and larger, in the penumbral region. The whole length in right ascension, determined by the time required for them to pass the slit when the clock work was stopped, was 16·5 sec. of time—a little more than 4′ of arc, or 111,000 miles. They extended from the spot which was nearing the western limb, nearly to the centre of the sun. At five o'clock they were still visible, but much fainter. When brightest I was able to see their form, even through h; the lines other than hydrogen which they showed, (notably D_3,) were limited to the immediate neighborhood of the spot group.

Yours truly, C. A. YOUNG.



WOOD WORKING MACHINERY.

Civil and Mechanical Engineering.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. BY J. RICHARDS, M. E.

(Continued from page 182.)

Sawing Machinery.

THE circular saw mill, to employ the popular name, is an American invention, or, as we should rather say, an American idea. Considered as an organized machine, it can be termed an invention, although the elements of which it is composed are old; circular saws with carriages for cutting timber were not new at the time of the introduction of the circular mill in the United States; but the bold idea of sawing all kinds of rough timber with the circular plate, mounted in portable framing, is a recent one. Our immense lumber interest developed mainly within twenty years, has created necessities that were never conjectured, at a time when the saw mill, like a grist mill, was a local institution to supply its immediate neighborhood. Cincinnati, Ohio, consumed, in 1869, 200,000,000 feet of lumber, of which at least 180,000,000 feet were sawed elsewhere. Lumber manufacture has, with our modern facilities for transportation, become centralized to a certain extent, and lumber has become a commercial staple. Yet so general is our timber growth, that outside of the cities, all sections of the country afford lumber for local uses. Because of its portable character, rapid performance and cheaper first cost, the circular saw mill has outstripped its rivals, and thus become the standard mill of our country for forest sawing. In its proper connection, drawings should have been presented in a previous article, but as we are yet on the subject of "sawing," it will not be out of place to introduce them here.

The illustration (Plate II.) shows a double circular saw mill, from the designs of the manufacturers, Messrs. Lane & Bodley, of Cincinnati, Ohio, who were among the first to manufacture and introduce mills of this type, and who have added many valuable improvements.

The term double relates to the use of two saws instead of one, as stated previously; the circular saw must depend upon the rigidity of the plate, to guide its course; and it is impossible to operate saws large enough to reach through our heaviest timber. This, with the difficulty of manufacturing plates of larger diameter, and their enhanced cost, has led to the modification shown in the plate, of two saws meeting in the same plane.

The frames of these mills are cast in one piece, and planed off to receive the several details, all of which, independent of the carriage, are mounted upon it. The top saw is adjustable in a vertical direction, to compensate for the wear of the saws by filing. The top mandril is driven from the main one by a belt passing over the pulleys shown, the tension being regulated by the idle pulley and swing frame, shown on the right of the engraving. The log carriage, shown on the left, is traversed by a rack and pinion geared to the main spindle with graduated cone pulleys, to regulate the speed.

In this train of gearing there is a friction-clutch that breaks the connection instantly for stopping and starting the carriage, and at the same time furnishes a means of graduating the feed as the saw passes through knots.

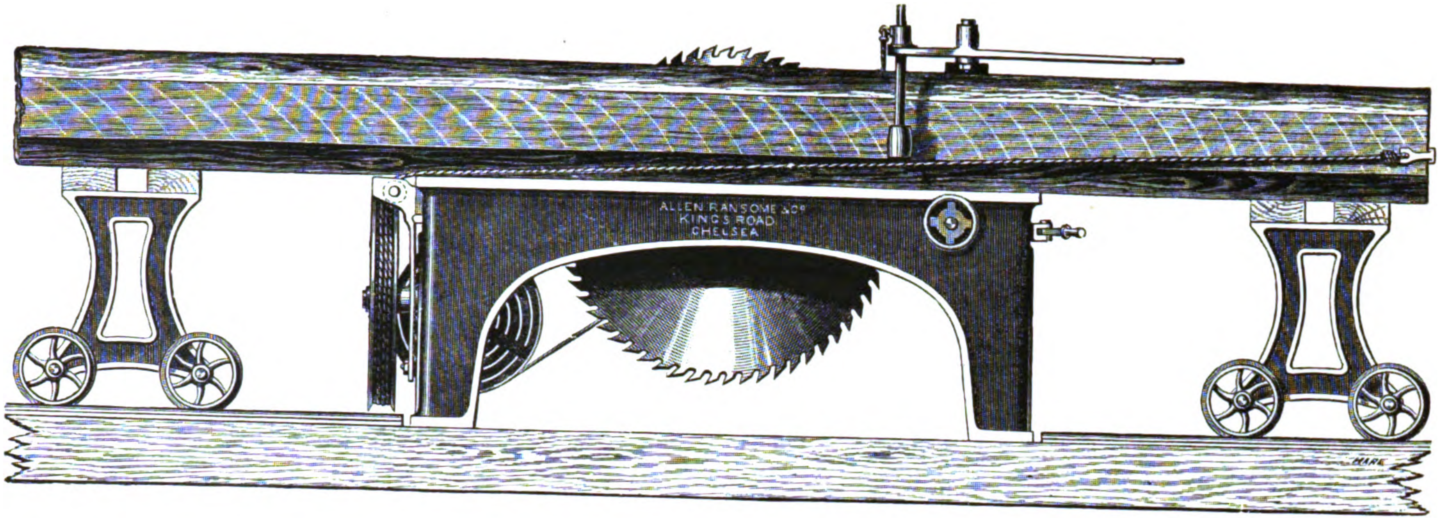
A revolving wedge is applied behind the saw to spread the stuff and clear the teeth, while the plate is stiffened and guided by lateral supports on the front.*

The log rests on the wrought iron cross-rails seen on the top of the carriage, and is moved forward, after each cut, by the vertical standards that slide on top; these standards are operated simultaneously by means of a worm and rack and pawl gearing seen on the left.

The dogs for holding the stuff are operated by a micrometer screw or tangent wheel gearing worked by hand-wheels. These mills will manufacture timber from 50 to 60 inches in diameter, cutting from 15,000 to 20,000 feet of boards per diem, using some 40 horse-power to drive them. They have been furnished to nearly all parts of the world, and it is, perhaps, a safe estimate to say that there are, in the State of Ohio alone, 2,000 men employed in the construction of circular saw mills.

Plate III. shows a side elevation of a contractor's or jobbing saw-bench, as constructed by Messrs. A. Ransome & Co., of London. It has guiding trucks at the ends, to be used when necessary in

* The revolving wedge was presented as an original invention in a paper read before the Institute of Civil Engineers in London, in 1858, but was extensively used in this country previous to that time.



WOOD-WORKING MACHINERY.

slabbing, after which the stuff is guided by a fence, in the usual manner.

Gig or Scroll Saws.

No other machine, in the whole range of wood-working tools, has been produced under so many modifications as the scroll saw. It would be impossible to define or describe the endless devices that have, from time to time, been introduced for working web saws, all directed to the same general end, but different in construction and operation. The many attempts to improve and change this form of machine must be ascribed to a dissatisfaction with the results, and it would be safe to say that none of them have yet given general satisfaction, and it would be, perhaps, equally safe to predict that no machine ever will. There are certain mechanical conditions or laws which must be observed in the construction of machines, in order to insure wear, durability and perfect operation; and it is impossible with our present knowledge of mechanics to build a scroll saw that will conform to these laws.

Rapid reciprocating motion is destructive to all machines, not only affecting their durability, but, of necessity, producing vibration of the framing or floors which furnish their support. Counterbalances are of but little avail, except as to changing the direction of vibration; and scroll saws, as a rule, shake everything that is near them.

This objection, although insurmountable and quite serious, is not the only one met with in the construction and operation of scroll saws. The vibration produced by the reciprocating parts, is as their weight multiplied into their velocity. A high speed must be attained, and to reduce the weight is the only means left to counteract the evil. Hence, in making scroll saw machines, the reciprocating parts and connections which should be the strongest, must, of necessity, be reduced to the smallest possible dimensions, and become perishable for want of strength and wearing surface. Another difficulty that applies to these machines is, that for many kinds of work, the sweep of the whole room, or, at least a large space, is required to turn the work, this severs the machine into two parts, with independent connections at the ends of the saw, and as no coincident movement of the top and bottom guides is possible, except by positive connection, springs have to be used for straining, in all machines that have what is termed a

"full sweep" for stuff. The spring is limited in the speed of its movement and irregular in tension, and may be regarded as a device of necessity rather than one of choice. These several difficulties, with which the inventors and manufacturers of scroll saws have to contend, furnish a sufficient explanation of the numerous attempts to produce machines free from some or all of them.

The modern scroll saw can be classed into three general modifications: saws strained by positive mechanism; saws strained by springs; and unstrained saws that are supported by anti-friction guides at their upper end above the work.

In the first class of machines, a reduced weight of the reciprocating parts is of great importance, whether a sash, levers, or flexible belt is used: this is the leading condition to be observed. The speed of the saw, in machines of this class, rarely exceeds 400 feet per minute, or 200 feet of cutting stroke, giving, of course, a slow performance; they, however, fill a place for deep cutting for inside or perforated work, but, in all cases, where the band-saw can be used, these machines must be considered an expensive investment.

Gig saws, strained by springs and having a clear open space for the stuff, are, perhaps, the most popular type. They have a greater range of adaptation, although not so speedy in heavy sawing, their claims for convenience quite balance this defect. The springs, if properly constructed and arranged, allow the saw to be held in open hooks at the end, so that it can be instantly removed for perforated work.

Deflecting or bending springs of metal are soon destroyed; those of wood, from their weight and inertia, limit the speed of the machines; but, to sum up the matter, it may be safely assumed that the gig saw will soon be confined to perforated and fret work. The spring-strained saw remaining the standard machine for this work.

Richards, Kelley & Co., of Philadelphia, manufacture a gig saw, illustrated in side and front elevation at Figs. 1 and 2, in which the saw is strained by torsional springs As there is no inertia to overcome in a spring of this kind, it can be operated at a very high speed, keeping a constant and regular strain upon the blade.

The base or main framing is cast in one piece; the crank-shaft is of steel, with the front bearing constructed on the "Schiele" curve, for compensating the wear; the top is of iron, pivoted for sawing bevel work; the saw is carried in open hooks, and can

be instantly removed. This machine is adapted especially for perforated work, as an adjunct to the band-saw machines made by this firm; although of superior construction, and with many advan-

Fig. 1.

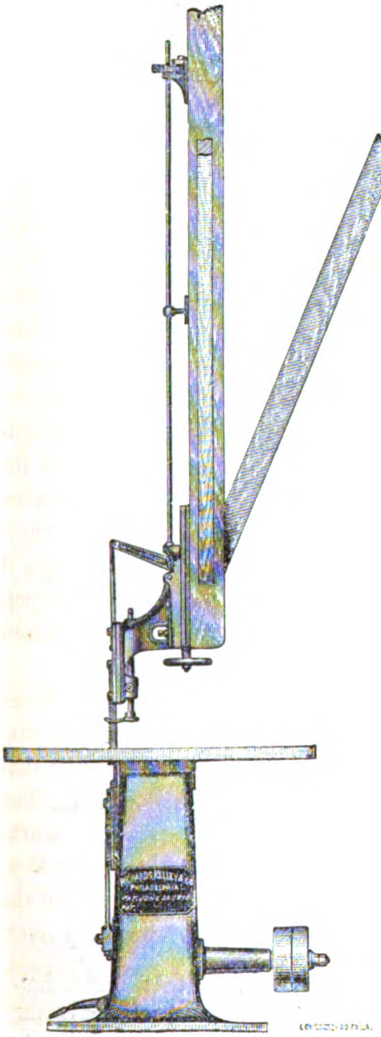
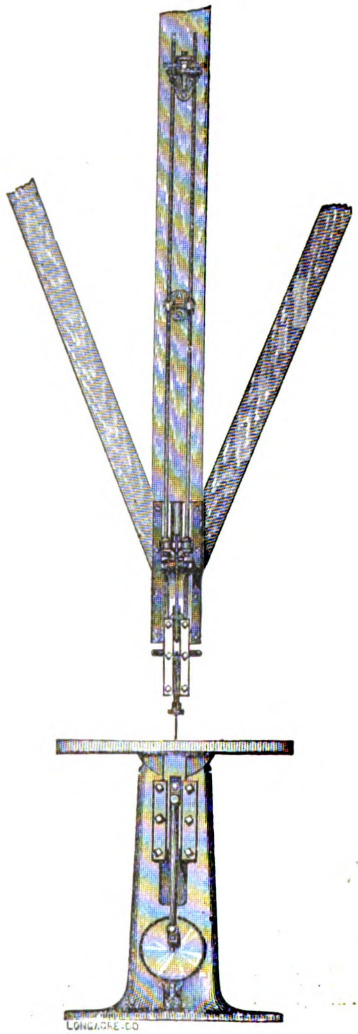


Fig. 2.



tages over the older types, it is to be recommended only where the "endless" blade cannot be used.

The unstrained web saw made its first appearance about the year 1860, in the United States. The first machines were of very sim-

ple construction, having a guiding-stock or bar below the table, with the saw fastened rigidly to its upper end, and the Pitmann connection jointed to the other. The saws used were very stiff and strong, having nothing to support them; they had, besides, to be specially manufactured for the machines. They were driven at a high rate of speed, making from 1,000 to 1,500 revolutions per minute; and for thin perforated work, when the width of the kerf was not an objection, they answered a good purpose; but, as they were not adapted to general uses, they had but a limited field.

The next modification of the scroll saw with unstrained blades, was introduced some three years later, in which a common saw was attached to a stock below the table, and its upper portion supported and guided by fixed guides, by this means narrow and thin saws could be used, and driven at a greater speed than was possible in machines where they were strained. The stroke was from $2\frac{1}{2}$ to 5 inches, which, with a speed of 1,000 to 1,600 revolutions per minute, made a good cutting movement, while the greater number of strokes and proportionately short feed at each stroke gave a smooth surface to the work compared with other machines.

Machines of this type had, previous to the introduction of the band-saw, come rapidly into use in the Western States, being used for nearly all kinds of scroll-sawing within their range, as to depth. A single firm has, within the last six years, manufactured and sold over 1,400 machines.

(To be Continued.)

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

By Col. O. W. Childs, C. E.

(Continued from page 174.)

Dimensions and Form of the Transverse Section of the Canal in Earth.

The water in the canal is to have a depth of 17 feet, and a bottom width, except in cases of turnouts, of 50 feet; 9 feet above the bottom, or at the base of the slope wall, the width is to be 86 feet; 17 feet above, or at the surface water line, the width is 118 feet; 21 feet above the bottom, or at the top of the slope wall, the space between the banks is 128 feet; at the inner top angle of the banks, 22 feet above the bottom, the width is to be $130\frac{1}{2}$ feet.

The inner face of the banks rise from the bottom angle 9 feet,

with a slope of 2 feet horizontal to one of vertical height; at this elevation a horizontal offset 6 feet in width is made in the face of each bank, from which a slope of $1\frac{1}{4}$ feet horizontal to 1 foot vertical rise is carried to the top of the banks.

The top of both banks to be 14 feet wide, and finished with a slope descending $1\frac{1}{2}$ feet from the front to the rear angle. An additional height is to be given to the banks in all cases of the connection of levels with the river.

Form of Transverse Section of Canal in the Rock Portions of the Summit Level.

The canal is to have a bottom width of 50 feet; it is to be 77 feet wide 9 feet above the bottom, and 78·33 feet in width at the surface water line. The inner faces of the rock on either side, are to rise from the bottom angle 9 feet high, with slopes of $1\frac{1}{2}$ to 1 respectively of base and vertical height, thence to 32 feet above the canal bottom, the faces of the rock to be cut to a batter of 1 inch to the foot rise; at this elevation offsets are to be made forming benches 9 feet wide, to serve the purpose of a towing path, and to prevent deposits of earth in the canal; above the benches, the rock portions are to be cut to a slope of 3 inches to the foot rise, and the earth overlying the rock to a slope of $1\frac{1}{2}$ feet base to one of vertical rise. The spoil banks of rocks to be laid with uniform slopes and elevation. To enable vessels moving in opposite directions to pass each other, the bottom width of the canal in earth is to be increased to 90 feet, and in rock to 105 feet. An enlargement of the prism is to be made at the head of all of the locks, and at other places, at least one in every mile of length of the canal. The bottom width of that portion of the canal occupying the Rio Lajas will be 100 feet; at all of the cuts through bars in the river the width at bottom is to be 150 feet. The locks, as designed for the canal, are 60 by 250 feet in dimensions of chamber, with 17 feet depth of water on their mitre sills. Appendix marked B, contains specifications of the manner of constructing the banks of the canal, also of the locks and other mechanical structures.

Herewith is presented a portfolio volume containing drawings of all the plans described in the specifications, also maps and profiles of the line of the canal in sections drawn to a scale of 4 chains to an inch; also a map $16\frac{3}{4}$ feet in length by $4\frac{1}{4}$ feet in breadth, upon which is delineated the profile and line of the canal on a scale of 64 chains to an inch, and showing in a more explicit manner the line and plan of the proposed communication between the two oceans.

Prices.

We come next to consider the prices to be adopted in the estimate of the cost of the canal. That they should be greater than would be required for similar work located in an improved section

of this country it is supposed is already conceded; the excess will in part consist, in the cost of transporting laborers and every description of tools necessary for their use in prosecuting the work; several of the staple articles of food for the subsistence of workmen, among the more prominent of which may be included salted provisions and flour; the machinery of mills for sawing timber, and carriages with which to transport it from place to place; this excess will also probably be further enhanced by the greater price to be paid for the same amount of mechanical and other labor.

The country along the river being with some inconsiderable exceptions uninhabited, and that along the line between the lake and the Pacific very sparsely populated, the erection of houses for the protection of property, and the residence of workmen will be necessary. The roads in the improved portions of this latter section are in a condition very unfavorable for use with lumber carriages, and the streams crossed by them are wholly destitute of bridges; the construction of new roads for hauling lumber, stone and other materials, will be extensively required in the more rough and uninhabited districts; these, together with the construction of boats for transporting materials on the river and elsewhere, the erection of cranes and other fixtures necessary in prosecuting the work, which must be principally done upon the line, will be attended with much greater expense, and will require more time than similar preliminary work in more favorable localities.

In Nicaragua, carts with wheels carved from solid sections of timber, are usually drawn by four oxen, connected in pairs with rudely formed bars of wood lashed to their horns; altogether a haul illy adapted to the heavy work required in the construction of the canal.

The horses and mules of the country, although quite numerous in the more populous portions, are entirely unaccustomed to the harness, and carriages of every description, except ox-carts of the very rude construction above indicated, are wholly unknown. Although the timber in the valley of the San Juan river in the immediate vicinity of the location of the dams and locks, also on the western slope in the valley of the Rio Grande, is of as large size, and as abundant as in any other equal portions of the country; the large quantities to be used in these structures will require in most cases a large area to furnish it; this, in connection with the hauling of the required quantity of stone from the quarries, will create the necessity of an extensive use of animal power in the transportation of materials.

Oxen of good form and size may be obtained in the country in sufficient numbers, and when made submissive to the yoke, will fully serve the purposes of this kind of animal power. Although the horses are less abundant, and of inferior size, they are generally of firm build; the requisite number, together with the first class of mules, could be procured in the country, at reason-

able rates, and when broke to the harness, would probably furnish a supply nearly equal to the balance of the demand for ordinary light teams that would be caused by the construction of the canal. The remainder, for the more heavy work, would probably be imported.

The foregoing remarks have reference to the comparative increased expense and delays, considered unavoidable, in the preliminary preparations for commencing the work, and attributable only to the remote, uncultivated and sparsely populated country, in which the canal is located.

There is yet a contingency of more importance, and liable by possibility to produce a much greater influence on the cost of the canal than any above named. I allude now to the contingent physical inability of the working classes to perform the ordinary daily labor necesary to a successful and rapid progress of the work, as compared with that ordinarily accomplished in the construction of similar works located in colder and more variable climates. Apprehending the necessity of relying mainly on the labor of foreigners to perform the work, a knowledge of the effect of a continued temperature, varying throughout the year something above that during the months of July and August in this country, upon their health was considered as among the essential elements that should constitute the basis of a fair and reliable estimate of the cost of the canal.

The grave consideration to which this subject was deemed to be entitled, induced an early attention to all existing or perceptible causes that might be regarded so liable to affect unfavorably, the health and vigor of workmen, upon which the progress and ultimate cost of the work so essentially depend.

It is not known that any more extensive works than the erection of large church edifices and some small fortresses, have at any former period been constructed in the country. These furnish some example of the ability of the resident citizens to perform labor; if, however, the labor performed in constructing these works was conducted with the same degree of moderation, as is the present common labor of the country, it would give but little evidence of value connected with the information sought.

Although the laboring classes, when under compulsory circumstances, are capable of great activity and of enduring much fatigue, in their ordinary avocations their movements, so far as observed, generally appeared to be tardy, and the times of their employment irregular; an exception, however, was found in a class of boatmen, numbering about 400, engaged in the transportation of freight on the river and lake; in these we have an example of physical labor and of exposure to the elements scarcely equaled in any country, and endured by them, with no perceptible prejudice, but apparently with benefit to their health. The boats used are generally of rude model, without covering, except for the protection of their food

and some small portion of freight; they are about 40 to 50 feet long and of some 6 or 8 tons, and in some cases of greater burthen. In an ascending trip on the river, each boat is propelled solely by the muscular power of from 8 to 10 men, and in a passage to the lake, are forced up an ascent on the length of the river of over 100 feet. The men retire at night on a narrow plank athwart the boat. with no other protection than that afforded by a single blanket, These men are of a very athletic form, and as a class, notwithstanding their exposure and apparent indifferent attention to the means of health, there are none more capable of hard service, or that are more robust and healthy.

However favorable the general health of the native born citizens of the country may be, and however great their capabilities for manual labor, it may be said that it does not follow that like capabilities can be invariably claimed for foreigners accustomed to a different climate and habits of life; the fact of the ability of the native citizens to perform the most severe exercise, and that not only without detriment but rather with advantage to health, is regarded at least as some evidence that foreigners, already accustomed to hard labor, may, when thoroughly acclimated, and with no unnecessary exposure, be capable of some labor in this, if not of the ordinary amount usually performed on public works in other countries.

A feature worthy of remark exists in the fact, that no swamps or pools of stagnant water were found in the country, west of the lake, nor is it believed that there are any between the lake and high tide on the Pacific, for a distance of some 25 miles in either direction from the line. The permanent streams contain soft water apparently of the greatest purity; and with the exception of the distance between San Carlos and Toro Rapids, and a section in the vicinity of San Juan del Norte, no swamps worthy of note were discovered on the San Juan River.

Of the party engaged in the survey, west of the lake, nine were unaccustomed to the climate. After a few months, a slight fever, followed by ague, prevented some of the number from continued daily exercise in the field; the disease being entirely under the control of medicine, was in all of the cases of short duration; during a stay of some seven months in this part of the state, illness in the party at no time interrupted the organization so far as to prevent a daily prosecution of the survey.

On the San Juan river some additions to the party of northern men were made, some of whom had been several months in the country; it consisted of twelve persons, exclusive of some native citizens. During the survey of this part of the canal, which occupied about 6½ months, or from March to September, the party generally enjoyed good health, and no individual was prevented by indisposition beyond a day or two from full service during the whole period. Of those engaged as axemen in clearing the line, two

were northern men, whose daily exercise exceeded that usually practiced by laborers employed in constructing canals, and with no deteriorations to health or constitution.

Having through inadvertence omitted to obtain from Dr. Lovejoy, the physician appointed to accompany the expedition, his opinion previous to his leaving the service of the company on our return in October last, and attaching much importance to any views he might entertain on this subject, the following correspondence was had.

Engineer's Office of the American Atlantic
and Pacific Ship Canal Co.
Syracuse, January 12th, 1852.

To WM. J. LOVEJOY, M. D., &c.

Sir,—Being desirous of arriving at conclusions as correct as under the circumstances is possible in regard to the effect, whether favorable or otherwise, that the climate of that portion of the State of Nicaragua, embracing the line recently surveyed for the construction of a ship canal from San Juan del Norte on the Atlantic to the port of Brito on the Pacific, will have upon the physical energies of the laborers to be employed in the construction of that work; in other words, the extent of the unfavorable influence of the climate, if any, upon the ability of the laboring classes both of Europe and this country to perform continued, or the ordinary daily labor necessary in the construction of the canal; and you, sir, having accompanied the party as physician and surgeon, also as rodman assisted in making the exploring surveys of all the routes examined, also the survey of the lines revised for adoption, and having pursuant to instructions taken meteorological observations, and notes of other existing conditions essentially connected with a truthful development of the information desired, I would thank you in aid of the object above stated, to favor me at your earliest convenience with the views you may entertain on this subject.

Very respectfully, &c ,

O. W. CHILDS.

O. W. CHILDS, ESQ.

Dear Sir,—Yours of the 12th ult. is received; I hasten to reply.

During the term of my employment in Nicaragua, a period of 19 months, there were few foreigners residing in the country, and only a small proportion of these being of the laboring classes, but little opportunity of observations of practical tests of the question alluded to in yours was afforded, if I except that of the party with which I was connected; beyond these, therefore, the opinions I may express are to be regarded as founded mainly in hypotheses.

In addition to drought, humidity and salubrity, physical climate comprehends the degree of heat and cold prevailing in any country. The substances most deleterious to health, especially in sections unimproved, being produced by the decomposition of animal and vegetable matter, the rapidity of this decomposition, and consequent amount of malaria set afloat in the atmosphere, much depends upon the degree of heat and moisture, elements essentially connected as well with the growth as the rapid decay of vegetation. The extent to which the atmosphere may become impregnated with this substance, consequently the extent of its effects upon the health of the people of the country are also subject to great modifications by the currents of air or the degree of the prevalence of the winds, and by the quantity and period of the rains; as the former cause will probably produce a material and highly favorable influence to health, upon the line of the canal in Nicaragua, it is somewhat to be regretted that more full and careful observations on this subject were not made.

The following statements show the average temperature, and the highest and lowest during each month, from September 1st, 1850, to September 12th, 1851, as observed each day at 6 o'clock A. M., and at 2 and 9 o'clock P. M., at several localities in the State of Nicaragua. Also the average and the highest and lowest tem-

perature during the months of June, July and August, at Lansingburgh, lat. 40° 47′, and the two latter months at Jamaica, Long Island, in lat. 40° 41′, as taken from the annual report of the Regents of the University of this State for the year 1850; also the average of the same months in 1845, at thirty-five localities; being all at which observations were taken in this State, as per Regent's report for that year; which is given for the reason that none of later date is at hand.

It appears from the above statement, that the mean annual temperature of Nicaragua is about 6° higher than the average of the months of June, July and August in Lansingburgh and 2° higher than July and August at Jamaica, Long Island, was about 6½ above that of the same months throughout this state in 1845; that the average of the highest temperature of each month is for the year in Nicaragua about 7° less than that of the three months at Lansingburgh, and about 9° less than that for the two months at Jamaica, and 6° less than that averaged for the two months throughout the State in 1845; also, that the average of the range in Nicaragua is 31° less than in Lansingburgh, 30° less than at Jamaica, and 28° less than the average in this State at the times as before stated, and that the average of any one month in Nicaragua is also less than either of the others given in the statement, thus showing a material difference in uniformity of temperature in favor of Nicaragua, and comparatively small difference in average temperature against it; the former requires a constant effort on the part of the human system to accommodate itself to these changes, and the latter also demands of the system efforts to enable it to sustain itself under the debilitating influences of the greater heat.

Dryness and humidity, however, as also heat and cold, affect the human system very much in proportion as they are constant and uniform, or as they are fluctuating and in extremes. Although the heat at a given locality might not of itself be so great as sensibly to prejudice health, yet, as an agent, when sufficient to favor a rapid growth and decay of vegetation, would, with a humid atmosphere, and subject to no mitigating circumstances, be productive of disease. In Nicaragua the degree of heat and its uniformity is shown in the statement; the amount of its action with humidity upon the other elements producing primary cause of disease, is only inferable in degree, from observations of the profusion or paucity of these elements, and of the effect of their continued operation upon the health of the people subjected to their influence.

Dr. Johnson, English surgeon in India, and author of a work on the influence of the tropical climates on Europeans, says, "That although in India, under the influence of exposure and neglect of temperance in diet, result ardent fever with some serious local determinations to the cerebral organs and to the liver, yet it is to be admitted, that with the practice of the proper precautionary measures, or such as were dictated by common sense and experience, at the stations, the very hottest have proved the healthiest of the seasons." "From the result of my observations in active field service in Bengal and in Ava, I am led to conclude that more heat, unless combined with intemperance in drink and other excessive habits of the people, is very rarely the direct cause of disease."

"The troops from Bengal and Madras, in crossing the desert of Kosseir, were exposed to a temperature ranging from 80° to 95° in the shade, and from 100° to 110° in the sun, yet with no indulgence in excesses, they enjoyed excellent health." "In Bengal, with all its vicissitudes of climate, the English have, by dint of prudent management, accommodated themselves to the climate."

In Nicaragua, as in other warm climates, the equable determination to the surface consequent on the higher temperature, produces a favorable influence on the general health. This remark is also applicable to the foreigner, by whom this augmentation of the sensible perspiration is borne, not only without injury to the constitution, but rather with an agreeable sensation. This view of its effects is fully sustained by the robust and hardy constitution of the native boatmen on the river, and by the improving health of those of our party, when their labor was most severe and perspiration excessive, during the last five months of our operations in the country.

In that part of the State with which I became familiar, the quantity of decaying vegetable matter on the surface appeared very much less than in the forests of the north. This I attributed to a less fall of foliage, owing perhaps to the perennial character, and to its being borne off by the much heavier showers which occur in that country, and to its destruction by the numerous ants which subsist upon it.

Year.	Months.	Average Thermo.	Highest Thermo.	Lowest Thermo.	Range.	Remarks.	Prevailing Winds.	
		State of Nicaragua.						
1850.	September...	72° 80	88°	71°	17°	Between Lake and Pacific.	South East	Wet season.
"	October	77°	86°	70°	16°	" " "	"	
"	November...	78° 42	86°	74°	12°	" " "	Easterly.	
"	December ...	77° 11	84°	72°	12°	" " "	East.	Constant and high—dry season.
1851.	January......	76° 40	87°	69°	18°	" " "	N. Easterly.	
"	February....	76°	84°	70°	14°	" " "	"	
"	March.......	77°	84°	72°	12°	" " "	"	
"	April	78° 83	88°	72°	16°	Fort San Carlos.	"	
"	May...........	78° 29	91°	68°	23°	Near head of River.	Easterly.	
"	June...........	77° 12	88°	71°	17°	" Castillo Rapids.	"	Wet season.
"	July...........	76° 98	86°	71°	15°	Las Balos Rapids.	S. Easterly.	
"	August.......	76° 20	86°	71°	15°	Near Colorado Branch.	"	
"	Sept. (12)...	79° 10	86°	74°	12°	At San Juan del Norte.	"	
	Total mean.	77° 42	86° 45	71° 15	15° 30			
		State of New York.						
1850.	June..........	71° 02	95°	45°	50°	Lansingburgh.		
"	July...........	73° 84	94°	55°	39°			
"	August.......	70° 15	92°	42°	50°			
	Total mean.	71° 50	93° 66	47° 33	46° 33			
1850.	July.	76° 65	98°	63°	35°	Long Island.		
"	August.......	73° 61	93°	60°	33°			
	Total mean.	75° 15	95° 50	61° 50	34°			
1845.	July..........	69° 22	95°	40° 60	45° 50	35 Localities.		
"	August.......	72° 38	91°	50° 26	40° 74			
	Total mean.	70° 80	93°	49° 93	43° 07			

The malaria produced by the decomposition of these substances, is, to a great extent, diluted and dissipated by the high and almost constantly prevailing winds from the northeast and east, during the dry season, which very much lessens the effect this substance would otherwise have in producing intermitting and remitting fevers, and tends to render these diseases less frequent and of a mild form.

There appears to be no swamps or stagnant waters west of the lake, excepting near San Juan, on the Atlantic, I discovered none in the vicinity of the line on the river, where, as I understand it, there is much work to be done. The water of the country, though warm, is generally good.

The diseases most common in the country, are intermitting and remitting fevers, and, as I was informed, diarrhœa and dysentery occur to some extent in some seasons, though very little fell under my observations. The fevers seem to rise more from a depressed nervous system, combined with checked perspiration and biliary secretion, than from the malaria of the country: if the latter is the prime agent, it appeared not to act with great force in the cases I saw: to restore these functions, appeared to be all that was necessary to restore the patient to health. The first sickness in the engineer party, commenced about two months after their arrival in the country. It was remitting fever, lasting from ten to fourteen days uncomplicated and easily controlled, yielding readily to febrifuge remedies, after a little previous preparation; this, in most cases, was followed by ague. Fever to some extent prevailed in the party, through November and December, after which, with some little exceptions, the party remained healthy.

From my observations, while in the country, of its climate, of the habit and health of the native citizens, and of foreigners, of whom there were a few residing in the city of Rivas, Granada and other ports of the State, I am of the opinion that it is as healthy as many sections of equal extent and improvement in our Western States, and that Americans and Europeans may reside there with at least as good health as is enjoyed by the people of those districts; that all would not suffer in becoming acclimated is also more than probable. Of the northern men comprising the engineer party, there were four, of whom myself was one, who, although equally exposed with the others, was not prevented by any disease of the country from continued daily service. In the general views I entertain of the salubrity of the climate, I believe I have the concurrence of Dr. Clark, of Pennsylvania, for many years a resident in the practice of medicine in Nicaragua, and of other intelligent gentlemen, the latter now residing there, with whom I conversed; I have also the authority of Dr. Clark in stating, that no case of yellow fever ever occurred in Nicaragua, and that the country, with some little exceptions, has ever been free from epidemic disease.

Dr. Drake, author of a work on the diseases of the valleys of North America, remarks, "that it was formerly believed that white men were incapable of enduring the heat to which they would be exposed in cultivating the field below 33° of latitude," a popular error of public sentiment long since exploded, leaving behind it evidence of the more modern improvements in the science of physiology and of the enterprise and perseverance of the people.

In constructing the canal the degree of exposure to disease will probably be different at different localities; with few exceptions, however, there will, in this respect, be much uniformity; the difference will be mainly produced by the difference in the amount of vegetable matter contained in the earth to be exposed (by excavations) to the air. The analysis of a specimen of earth, obtained from the borings near San Juan, gave of vegetable matter $16\frac{1}{4}$ per cent.; the analysis of another specimen, obtained a little more distant, gave $11\frac{5}{8}$ per cent. These specimens were obtained from localities supposed to contain a much larger proportion of vegetation than any other upon the line. The latter, however, from ordinary inspection, appeared quite a pure earth, and probably did not vary much in composition from many of the alluvial formations of the valleys of the country.

Notwithstanding that an equable temperature, averaging something higher than that of the hottest months in this country, may not alone be productive of disease, and although the disease most common in such countries may be less malignant, less frequent, and less in variety than those of a colder and more fluctuating climate, yet I am aware there is a prevailing opinion, that the uniformly higher temperature is productive of that degree of lassitude and general depression which disqualify men for active service, and renders them incapable of much physical exercise; that this conclusion, if correct as a general principle, is applicable to

the line of the canal in Nicaragua only in a very limited degree, is strongly indicated, if not rendered certain by the strong constitution, uniform good health, and great physical powers of the boatmen and of many others of the laboring classes in the country, and the beneficial effects attending those of the party whose daily exercise, while surveying the river, exceeded that of any common laborer on public works.

The idea that the heat of Nicaragua is of itself sufficient to produce disease, is not entertained. The large annual fall of rain, by frequent and heavy showers, bears with its waters in passing from the surface much of the elements of disease, and being accompanied with winds, tends to the coolness and salubrity of the atmosphere during the wet portions of the season. In the dry season, the temperature through the day is rendered agreeable by almost constant high winds; the nights of both seasons are generally cool.

The prevalence of sickness among the workmen will much depend on the degree of temperance they practise in eating aed drinking, their exposure, and the general care and attention they give to the means of health. That some, with the practice of all reasonable precautions, will, in becoming acclimated, to some extent, be sick, is quite probable, and others, with whose constitution the climate is better adapted, will reside there with uniform good health; this is the effect in cases of emigration in this latitude from the eastern to the western states, and of foreigners in this country.

On carefully considering the causes of disease as they exist in Nicaragua, I can discover no good reason for apprehending more sickness in constructing the canal in that State, than has been experienced on some portions of the public works in this and some of the western states; and that men with temperate and industrious habits, being well provided with comfortable lodgings and a diet adapted to the climate, and subject to no unnecessary exposure, will, after becoming acclimated, do nearly as much labor as was formerly done on similar works in the new or unsettled portions of the State of New York.

A peculiar feature on the Isthmus between North and South America, is the valley extending from ocean to ocean along the line as surveyed for the canal, and through which there is almost at all times an invigorating current of air, which will be increased as the improvements on the river become extended.

The construction of the canal through some of the valleys of this State was attended with much sickness and loss of life, that might have been avoided by a judicious system of medical police. It is to be hoped that the company, in constructing that canal, will, from considerations of philanthropy, if not from motives of interest, pay more attention to the subject.

On that canal, as on most others in new or uncultivated districts, the health of the workmen, consequently their ability to perform labor, will, as before remarked, much depend upon correct regimen, regular exercise with proper guards against exposure, while intemperance and general indulgence in excesses will result in crippled energies, disease and death. West of the lake the uniform temperature and delightful breezes which sweep across the country from lake to ocean, produce a salubrity of climate scarcely excelled in any country. In the immediate vicinity of San Juan, on the Atlantic, for reasons before given, I think the country less healthy.

Very respectfully, &c.,

WM. I. LOVEJOY, M. D.

Salina, Feb. 9th. 1852.

(To be continued.)

Spirits from Mosses and Lichens.—Sternberg and Stahlschmidt have described a method of manufacturing spirit from these materials. The subject is a highly important one, which may in time lead to the substitution of these, as spirit-yielding products, for the grain at present used.

THE ALLEN ENGINE.

BY CHARLES T. PORTER.

THE ALLEN ENGINE belongs to the class of variable expansion engines having an invariable exhaust; but it is distinguished from all others of this class by two important features.

The valves receive positive movements, and work in equilibrium.

These features, together with the action of the valves, which, by short movements, open large areas for admission and release of the steam, with correct lead, enable this engine to be run at the speed at which steam engines ought to work.

While the efforts made with other variable expansion engines to attain any considerable increase of speed have uniformly failed, from the defective action of the valves when urged beyond a moderate rate, and have been abandoned, except so far as the desired object could be approximated by employing a long stroke; in this engine, on the contrary, the valve-action is perfect at any speed, the velocity of the *closing*, as well as of the opening, movements increasing with their frequency, and a proper speed of piston is attained with a stroke of only moderate length.

When it had become established that this system of valves and valve-gear possessed such a remarkable combination of features favorable to the employment of a speed more advantageous than the traditional one to which engineers had hitherto been confined, it was evident that the time had come for the solution of the other mechanical problems which such a speed involves.

This labor has been steadily and successfully prosecuted, partly in this country and partly in England, during the past ten years, and an engine has been produced which realizes all the advantages well-known to be attainable only by the combination of higher piston-speed with shorter stroke; as, among others, great power in small compass, improved steadiness and uniformity of motion, the avoidance of mechanism for multiplying motion, imparting to belting its desired velocity from small drums, and increased economy of fuel; and which, at the same time, fully equals, and even surpasses, the best slow-working engines in those very respects in which the improved speed has been thought objectionable; as, in the durability of its working parts, in freedom from warming, in the percentage of its power usefully exerted, in the small amount of care it requires, and in silence and smoothness of running, and

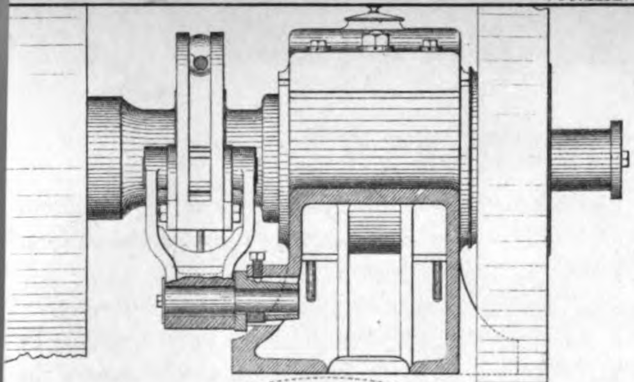


Fig. 7.

Sustaining Arms of the Link and their adjustment

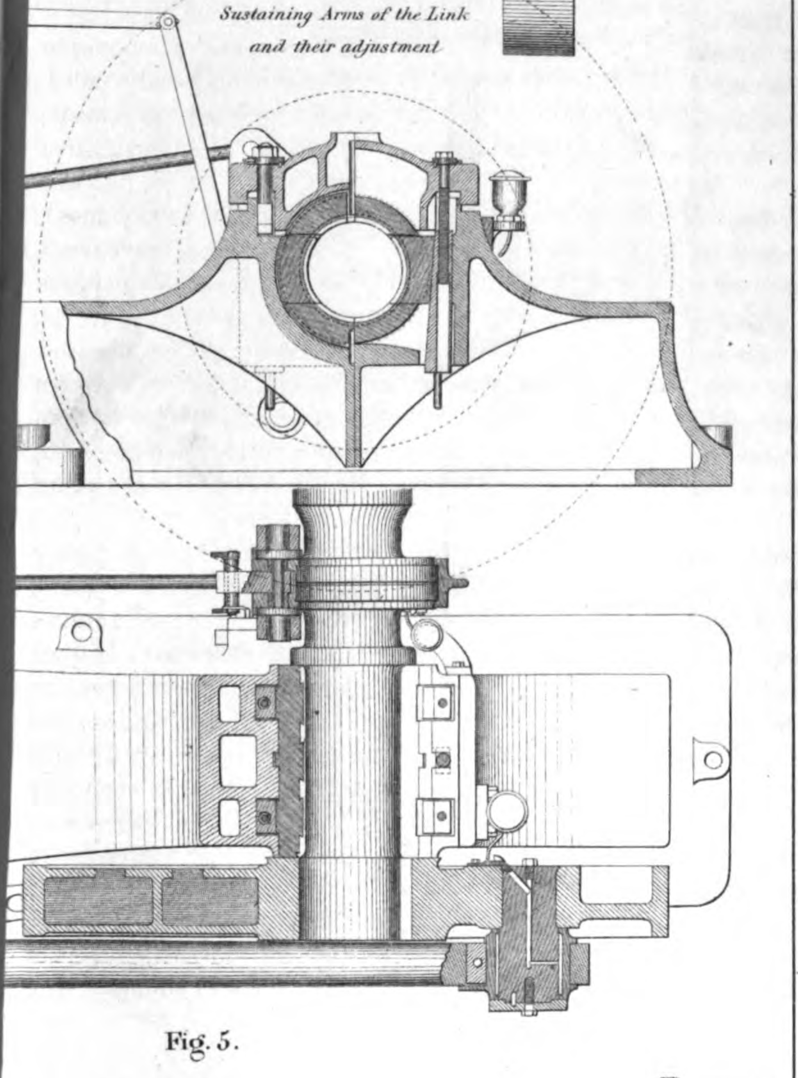


Fig. 5.

which will be found to bear to engines of former styles a relation very similar to that which the turbine bears to the overshot water-wheel.

This engine is fully shown in the accompanying plates, and its distinctive features will be explained in the following description:

The Valves.—These are shown, in section, in Figs. 1 and 4, Plate I. Each admission-valve is an open rectangular plate, with parallel faces, working between opposite parallel seats, and opens four passages into the port, giving a free admission and sharp cut-off.

The exhaust-valves are made on the same principle, each one opening two passages for release of the steam. The exhaust area is from one-tenth to one-eighth that of the cylinder, and the valves have an excellent lead and rapid movements. They are so placed as completely to drain any water from the cylinder. The amount of waste steam-room in ports and clearance is quite small.

All the valves work in equilibrium, both of pressure and current. The faces and seats, being free from friction, even from the weight of the valves themselves, continue steam-tight for years, and the bonnets are so made as to be, when necessary, easily re-adjusted. This is a feature to be best appreciated by those who are aware of the enormous force required to work the slide-valve under steam-pressure. The valves are easily got at, it being necessary only to remove the bonnets, which have scraped joints, entirely tight without any packing whatever. All steam-joints, in these engines, are made in this manner.

The Valve-Gear.—The valves receive their motion from a "link" worked by a single eccentric, which is set on the shaft in such a position that the vibrations of the link, at its point of suspension, are coincident with the strokes of the piston of the engine. From this link independent movements are given to the admission and exhaust-valves. The latter are driven from a fixed point at the extremity of the link, and their action is invariable. The admission-valves are driven from a block, the position of which is adjustable in the link from the point of its suspension, at which point the motion given to the valves just draws off their lap, but does not open the ports, up to the point at which steam is cut off at the half-stroke, beyond which steam is not admitted to the cylinder in these engines. The position of the block in the link between these

extreme points is varied by the action of the governor, giving a perfect regulation to the speed of the engine.

The point of suspension of the link is so fixed as to give equal openings of the ports, and to cut off the steam at equal portions of the stroke, at the opposite ends of the cylinder. The illustrations show an engine running forward. In engines designed to be run the opposite way, the link is made to extend from the point of suspension downward, and for reversible engines both ends of the link are used.

The connection to the admission-valves is fitted with a hook, which is readily disengaged, and the valves worked by hand, requiring a scarcely appreciable exertion of force, so that the engine can be blown through before starting, and can be started from any position, except on the dead-centres. The joints in the valve-gear are formed by steel pins turning in steel ferrules in the rod-ends, both being hardened and ground to a proper cylindrical fit. These joints show no sign of wear after running for years, while they require no adjustment, and admit of no derangement. The construction and movements of the valves and valve-gear are well represented in the plates, and are submitted to the critical examination of engineers.

The Piston Speed.—The speed of piston adopted for these engines is 600 feet per minute, and the stroke is, in the smaller sizes, twice the diameter of the cylinder, diminishing gradually, in the larger engines, to about one and a-half times the diameter. Thus an engine of 20 inches diameter of cylinder by 36 inches stroke makes, say, 100 revolutions, and one of 6 inches diameter of cylinder by 12 inches stroke, makes 300 revolutions per minute. This is, for them, a moderate speed; they are sometimes run much more rapidly, and with entire satisfaction. Smoothness of running is a marked feature of these engines. They have practically no centres, and their action seems more that of a rotary than of a reciprocating engine.

Their adaptation for running at a speed which has always been looked upon as highly desirable, if it could but be successfully attained, rests chiefly upon a principle of crank-action of supreme importance, which is now, for the first time, practically applied, if, indeed, it is not now first understood. Attention is invited to an explanation of

The Reciprocating Fly-Wheel.—The speed of the piston, piston-

rod, cross-head and connecting-rod of an engine, which are, collectively, termed the reciprocating parts, is not uniform, but, commencing from a point of no motion on each dead-centre, it gradually increases up to the middle of the stroke, where it is equal to the speed of the crank-pin, and from this point it is reduced to nothing again at the end of the stroke. In stating the piston-speed of an engine, engineers always name the average speed in feet per minute, which is obtained by multiplying the number of strokes made in a minute by their length; but the maximum speed, at the middle of each stroke, is 57 per cent. greater than the average.

The reciprocating parts of an engine are properly considered as a projectile, which is put in motion by the force of the steam, and has its velocity gradually accelerated by this force from the commencement to the middle of the stroke.

But, obviously, the acceleration of the motion of this projectile cannot be uniform during the half-stroke; for, if it were so, then at the middle of the stroke it would cease abruptly, whereas it really here passes insensibly into retardation.

In fact, and this is the really important point which has been so little observed hitherto, the acceleration of this projectile is most rapid precisely *on the dead-centre.* Where motion begins to be imparted to it, there it is imparted most rapidly. From this point the acceleration diminishes, until at the mid-stroke it has become nothing. The distinction must be carefully observed between velocity already acquired and acceleration. When the former is greatest, the latter has ceased; where the velocity attained was nothing, there the acceleration was greatest. But it is the acceleration which requires the exertion of force to produce it; and the manner in which the force required to impart its velocity to this projectile diminishes from the commencement to the middle of the stroke is very remarkable.

We come now to the practical application of this law of crank-action. When steam is admitted to the cylinder, its first work is to put the reciprocating parts in motion. No force can be transmitted *through* them to the crank, except the excess over the amount that must thus be absorbed in them. But this action takes place in all engines. The reciprocating parts always have weight, and are accelerated and retarded in precisely the same manner. What advantage, in this respect, has this engine over another?

Answer. The force required for this purpose varies as the weight

of the parts, and as the square of the velocity which is imparted to them in moving through a given distance. The reciprocating parts of engines are usually so light in proportion to the area of the cylinder, and their speed is so slow and stroke so long, that the force required to impart motion to them, expressed in pounds pressure on the square inch of piston, is but trifling.

But in this engine, the reciprocating parts are made as heavy as possible, without giving to them a clumsy appearance, in direct violation of the received maxim, that these parts in high-speed engines must be made as light as possible; then a short stroke is employed, and a speed which is of some use in this respect as well as in others, and thus there is interposed on each centre, between the force of the steam and the crank, the inertia of a mass, sufficient to absorb the former in great measure, and to impart it to the crank during the latter portion of the stroke, when the pressure in the cylinder has fallen by expansion to little or nothing above the atmosphere.

The reciprocating parts thus act as a reservoir of force, precisely as the fly-wheel. They become not the mere means by which, but rather the medium *through* which the force of the steam is transmitted to the crank. They remedy the great defect of the crank-motion, which is, that at the beginning of the stroke the force of the steam is exerted more directly to punish the engine than to rotate the crank. They remove the serious objection to working steam at a high grade of expansion, that the engine is driven by a succession of blows. They save the crank and shaft and frame from sudden shocks, and cause the engine to run with a gliding motion that is really surprising to witness.

The contrast between the efficiency of these parts, for this purpose, in this engine, and their inefficiency, as ordinarily employed, can be exactly shown.

(To be Continued)

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 166.)

We present the following, condensed from the text of *Publication Industrielle par Armengaud Ainé.* 9th Vol. 1860.

The application of pulleys, cones and drums, for the transmission of power has become so general that, with cog-wheels, they constitute a large part of the stock of patterns carefully kept for use.

There does not exist, in fact, an organic means of transmission more simple and inexpensive than that by the agency of belts.

In most cases, the belt and pulley form a mechanical agent at once the most convenient, the most easily erected, and requiring the least combination of parts; it suffices only that they be in exact proportions: 1st, to obtain the necessary speed, and 2d, to communicate the required power.

This mode of transmission has the advantage of smooth and quiet action, of light weight in comparison to the power transmitted, and of less liability to destructive wear and tear, and consequent accident as with the use of gearing.

In accordance with these facts, gearing has been replaced, of late, by belts and pulleys, even where considerable powers are transmitted.

To gain all the advantages which such a system is expected to furnish, it is absolutely necessary to fulfil several essential conditions, without which the best results cannot be obtained; for instance, if the pulleys be not of proper diameter, the speed would not be in the ratio desired; again, if the pulley faces be too narrow for the power transmitted, the belt will slip; or if, on the contrary, all the dimensions be augmented beyond the requirements of each case, material would be uselessly wasted and power continually lost in giving motion to needless weight of parts.

The principal questions concerning the belt and pulley arrangement are the following:

1st. Determine the diameters of the pulleys according to the number of revolutions their respective shafts are to make.

2d. Calculate the dimensions of the belt according to the power it is to transmit, and decide the diameter of one of the pulleys.

3d. Ascertain, also, the proportions of the different principal parts of each pulley in conformity to the width of the belt.

The speeds of pulleys connected by belts is in the increase ratio of their diameters.

The width of belts is calculated from the tensile resistance of the leather. We merely examine here the leather belts most generally used in machine shops and factories.

In closely observing the action of belts on pulleys, it is found

that the power which they transmit depends on the amount of friction developed on the surface of the pulley and upon a certain degree of tension applied to the belt when put on.

M. Morin has furnished us with the following:

1st. If the belts are sufficiently tightened, they do not slip, but transmit the speed in a constant ratio, and inversely to the diameter of the pulleys.

2d. In the transmission of power by endless rope or belt, on pulleys, from one shaft to another, the sum of the tensions in both folds remain constant, in a manner, that if the driving fold is overburdening itself, the driven fold is relieving itself to the same amount, and that the sum of both tensions is the same when the machine is stopped.

3d. The ratio between friction and traction exercised by the primitive tightening is very nearly proportional to the degrees of contact with the pulleys when within the ordinary limits, varying, in practice, but little from $\frac{1}{4}$ to $\frac{3}{4}$ the circumference.

Belts should not be subjected to working strains over 284 lbs. per square inch.

Action of Belts.

1st. The friction developed at the circumference of pulleys is proportional to the primitive tightening of the belt, and depends also on the angle in which the belt envelopes the pulley, and, further, on the nature and condition of the surfaces in contact.

2d. The friction is independent of the diameter of the pulley and of the width of the belt.

Most of the belts in actual use for transmitting small powers have larger dimensions than the calculations would give, for the reason that belts are frequently overloaded, and the quality of the leather not always of the best. They sometimes are made to carry 280 lbs. to the square inch, instead of 140 to 210, to which latter strains they are generally admitted in practice.

For the transmission of great power, there is much interest felt in employing the very best leather, in order to reduce the width of belt and pulley as much as possible.

(To be continued.)

Mechanics, Physics, and Chemistry.

THE SUN.

(A course of five lectures before the Peabody Institute of Baltimore, January, 1870.)

By B. A. Gould.

(Continued from page 194.)

The sun's distance and size being known, our next question has regard to its weight, or mass as it is called, when very large bodies are spoken of. Here, too, we have abundant and trusty information, and it has proved easier to weigh the sun than to measure his distance. The weight of any terrestrial object is simply the attraction subsisting between it and the earth, being measured by the force necessary to lift it. Now, by means of large masses of metal or other very heavy material, it has been found possible to exert a measurable gravitative attraction upon small objects, and a comparison between the amount of attraction which a body of known weight thus exerts, and that exerted by the earth as shown by the weight of the object itself, gives us the actual mass of our planet. In this way the mass of the earth has been found* to be a little less than six sextillions of metric tons (of about 2,205 pound avoirdipois). One more step of the same kind enables us to compare the attraction exerted upon other heavenly bodies by the sun and the earth respectively; and it has thus been established that the mass of the sun is very nearly 327,000 times that of our own planet.

We have seen that the diameter of the sun is about 108·8 times that of the earth. His volume or total size is therefore about 1,288,000 times, while his weight is only 326,800 times that of our

* Treating the earth as an exact sphere, of a radius equal to its mean radius, the mean density 5·44, determined by Reich, gives for its mass $5{,}891 \times 10^{18}$ metric tons. Very large numbers are most conveniently written in this form, as multiples of some power of 10; the exponent of the power denoting the number of zeroes to be appended to the factor given. Thus 5×10^6 denotes five millions, 3×10^9, signifies three billions, 7×10^{15} is seven quadrillions, &c. Some English writers still use the word *billion* to denote a million millions, instead of a thousand millions; but this inconvenient nomenclature, which has sometimes produced intolerable confusion, seems to be rapidly disappearing before the established usage of other countries. The name corresponding to any power of 10 is easily recognized upon dividing the exponent by 3 and subtracting 1 from the quotient.

planet. Consequently, he must consist of material four-fold lighter on the average than that of which the earth is composed, his specific gravity being on the whole, only about 1·38 times that of water.

Since the attraction exerted by a sphere is proportionate to its mass, divided by the square of the distance from its centre, it is easily seen that the weight of any object at the surface of the sun must be 27·6 times as great as the weight of the same object upon the earth. Anything let drop near the surface of the earth will fall about 16 feet during the first second, but near the sun's surface it would fall more than 444 feet during the first second; at the end of the next it would have acquired a velocity equal to that of a cannon ball as it leaves the most powerful gun, and even if let fall from the height of two miles, it would traverse this distance in less than five seconds.

It was once thought that an exterior shell surrounding the true body of the sun was the source of his light and heat, and that within this shell was a comparatively cool, dark body, which might possibly be inhabited by beings not very unlike ourselves. Now that we know the case to be otherwise, and that the interior of the sun must be at a temperature surpassing that of the fiercest fires which can be produced by human art, the question of habitability loses its significance,—unless perhaps from a theological point of view. But a consideration which might well have been borne in mind is the vastly greater weight which all objects at the sun must exhibit by reason of the attraction of his immense mass. A man of ordinary size would there weigh 5000 pounds, and although we may hardly endorse the younger Herschel's statement that "he would be crushed as flat as a pancake by his own weight," we must concede that it would be a somewhat fatiguing exercise for him to run up and down stairs very often, and that the sun's surface would be rather "a hard road to travel."

Before passing from a consideration of the dimensions of this stupendous orb, I have only to add that the most careful measurements have failed to show any deviation in its form from that of a perfect sphere. All other bodies in our system, whose diameters are of measurable magnitude exhibit a flattening at the poles, and a corresponding increase of dimension at the equator, apparently the result of their rotation while in a plastic condition. No such excess of equatorial diameter has been detected in the sun, and indeed a simple calculation shows that by reason of his enormous mass, and

the comparative slowness of his rotation, the amount of polar flattening due to this influence ought not to exceed the twenty-fifth part of a second, which is a magnitude not measurable by our astronomical instruments.

Although astronomy has taught us that the sun is the great centre of the system to which we belong, that our earth and her sister planets are bound to him by the most indissoluble of material ties, and revolve around him in eternal subservience; these are truths not apparent to the ordinary observer. The untutored intellect recognizes but two of the characteristics which render him the fountain of life and energy to our universe, namely, his dazzling radiance and the copious heat of his beams. To these, let us now turn our attention.

The most vivid sources of light which human art has thus far been able to develop are the calcium light, or the incandescence of a piece of lime, subjected to the jet of the oxyhydrogen blow-pipe, and the yet more brilliant electrical discharge between carbon points at the electrodes of a powerful galvanic battery. Both of these have been compared with sunlight by the French physicists, Fizeau and Foucault, the same investigators to whom we owe the exquisitely ingenious experimental determinations of the velocity of light to which I have already alluded. Their comparisons* were chiefly made by means of the photolytic or chemical power exerted by these several sources of light, but additional experiment showed them that the respective illuminating powers were essentially in the same ratio. Forcing a burning jet of mixed oxygen and hydrogen upon the lime by a pressure of about $\frac{2}{3}$ pounds to the square inch [20 kilo. upon a surface of 430 square centimetres], they could only obtain an intensity equivalent to the 146th part of that of sunlight. With the electric light they succeeded on one occasion in producing a brightness about $\frac{5}{13}$ths that of the sun, to attain which it was necessary to use 46 elements of a Bunsen's battery, each element containing three cylinders of carbon, $2\frac{1}{6}$ inches of internal diameter (5 centimetres), and immersed $3\frac{1}{2}$ inches (9 centimetres) deep in the acid. The calcium light interposed between the eye and the sun, appears like a black spot upon the solar disk.

Of the character of the sun's light we will speak hereafter. The marvelous revelations which its analysis by means of the spectroscope have made within the last ten years, are not unfamiliar to

* *Comptes Rendus de l'Academie des Sciences*, XVIII., 752.

the lovers of science, and have afforded much information concerning the materials of which the outer layers of the sun consist, as regarding their condition; and the wonderful powers and capabilities of this new instrument of research are continually finding new illustrations in the rapid march of discovery now going on.

The French physicist Pouillet made in the year 1838 a series of interesting and important researches* concerning the amount of heat emitted by the sun, and to these we owe a large part of our knowledge upon this subject. In measuring quantities of heat we must of course have a unit or standard of measure. That most frequently employed is what the French call a calory, being the amount of heat requisite for raising the temperature of one kilogram of water at the melting point of ice by one degree of the centigrade thermometer. This is equivalent to the heat which would raise the temperature of a pound of water by a little less than 0·82 Fahrenheit. Somewhat less than 220 calories are required for raising a pound of iced water to the boiling point.

Very careful and extended experiments with apparatus devised for the purpose gave Pouillet for the amount of heat received in each minute by the direct rays of the sun at the mean distance of the earth 17·633 calories to the square metre [1·638 calories to the square foot]. From this our knowledge of the earth's distance, and of the dimensions of the sun enable us readily to deduce the total amount of heat emitted by the sun in any given time, as well as the amount from any given area of his surface. Thus we find that each square metre upon the sun's surface radiates 13,524½ calories every second [or each square foot 1256·4 calories]. Here we have a definite numerical expression for the force which the sun is unceasingly pouring out in the form of heat. The discoveries of the last quarter century have established the fact that the different forms of material activity are convertible one into another, under the proper conditions, each of them being a particular form of force, which might be manifested in some other way. The amount of force of any one sort equivalent to an amount of force of any other sort has been carefully determined, and we thus find that the mechanical equivalent of the heat constantly issuing from each square metre of the sun's surface is about 5,729,893 kilogram-metres [or 41,444,700 foot-pounds] in each second. In other words, the force radiated in a single second from each square metre of the sun in

* POUILLET *Comptes Rendus*, VII., 31.

the form of heat would lift a weight of 207 tons to the height of 100 feet, being more than 75,000 horse-power. From each square foot the radiation is between $\frac{1}{16}$ and $\frac{1}{11}$ as much. In a single minute the sun's heat would melt a layer of ice covering his whole surface to a thickness of 10·239 metres [or 33·6 feet]. The amount intercepted by the earth alone would suffice to melt a shell of ice $29\frac{1}{4}$ metres [$69\frac{1}{2}$ feet] thick, encompassing our globe; while the total annual emanation of heat from the sun would raise $25{,}760 \times 10^{21}$, or nearly 26 septillions of metric tons of water from the freezing to the boiling point.

The temperature of the sun's surface corresponding to this radiation cannot be exactly determined, owing to our want of knowledge as to the radiant power of its materials. It cannot well be below 14,000° C. [25,000° F.]. The highest temperature yet produced by man is that evolved by the combustion of charcoal in oxygen, which Bunsen estimates at 10,000° C. [18,000 F.,] and this is about $\frac{5}{7}$ of the lowest reasonable estimate for the temperature of the solar surface. Coal burning at the rate of one pound per square foot in about 2 seconds would attain this temperature, and Rankine has estimated that in the furnaces of powerful locomotive engines a pound of coal to each square foot of grate surface is consumed in from 30 to 90 seconds, yielding a heat from $\frac{1}{15}$th to $\frac{1}{45}$th part as intense.

Adopting this estimate that a heat equal to that emitted by the sun might be attained by the combustion of coal at this rate of half a pound per second to the square foot, it is easy to find how long a time the whole mass of the sun would last, were it composed of coal burning at that rate, and furnished, moreover, with an unlimited supply of oxygen to support the combustion. Performing the calculation we find that the entire sun would be consumed in a little more than 4000 years; that is to say, within a period no longer than that over which human history extends. Such a supposition is of course out of the question; the very statement of it suffices to manifest its absurdity; yet the wondrous problem which it discloses to us seemed for a while to baffle all inquiry. Various attempts have been made to explain it, but each in turn has been found to require some assumption, which has proved altogether inadmissible, and this problem of the origin of the sun's light and heat has been among the most prominent and the most perplexing of all which recent astronomy has presented. Regarding its solu-

tion I shall speak hereafter; for the present it must suffice to call your attention to the difficulty of finding a satisfactory answer.

And now what is this sun of ours? This centre, around which 8 large planets, with not less than 18 satellites and 109 small planets are known to revolve, beside comets unnumbered and countless swarms of meteors; this luminary, whose fervent and dazzling beams radiate, and have radiated for ages, with a profusion which has shown no signs of failing, although the most vehement combustion fails to equal it in heat, and the most intense electrical action falls short of it in light; which, notwithstanding the enormous floods of energy, which it is pouring out has decreased neither in weight nor size to any extent which human skill has sufficed to detect? How is it poised in space? Of what does it consist? And does the realm of nature show any other object comparable with it in magnitude or in character? These are among the questions which force themselves upon our consideration.

The sun is a star, apparently not unlike the most of those which gem the sky by night. This seems a better statement than to say that the stars are suns, although it would be difficult to give a good definition for either word; for our idea of a sun seems to imply that it is a centre for a system of planets or satellites dependent upon it for their light and radiant heat. There is some ground for believing this to be the case with some fixed stars, but for supposing it to be so with most of them there is no reason other than the supposed analogy,—an analogy which, for the very large class of double stars, at least does not exist at all. But that the sun is a star,—one of the same great company which spangle the firmament, and indeed one of the countless myriads which compose the single nebula which we see all about us like a ring, and call the milky way,—seems a well established fact. Here as with them, that same law of gravitation holds unrestricted sway, which double stars reveal to us as the guide and controller of their motions. Like many of them it is variable in its light, although only to a small extent and with a long period. Like them it is journeying through space, drawn by some powerful attraction, or performing a stupendous orbit around some centre which astronomers have not yet succeeded in recognizing. Its annual motion in this orbit has been computed by Otto Struve* to be 150,000,000 miles,—corresponding to more than 400,000 miles a day.

* *Bestimmung der Constante der Präcession.* Mem. Acad., St. Petersb., 1841, Nov. 19.

And, notwithstanding its awful magnitude, we must still regard the sun as a comparatively small star, at least as not above the average size. There are a few stars whose parallax has been satisfactorily measured, using the diameter of the earth's orbit as a base-line, and thus determining the very slight variations in their apparent position, according to the time of the year. For these stars we have a crude knowledge of their distance; for others we know only that their distance is greater yet. Of all the annual parallaxes which have been measured, the largest value does not amount to a single second of arc,—a quantity which you will appreciate when you remember that it is the apparent thickness of an average human hair seen from a distance of about 130 feet. An angle smaller than 0·1 s. is hardly recognizable or measurable by astronomical instruments. The corresponding remoteness is somewhat more than 2,000,000 times the earth's distance from the sun, being about 191 trillions of miles, an interval which light would require $32\frac{1}{2}$ years to traverse. This is about the distance of the pole star; and the number of stars nearer than this seems to be comparatively small. At such a distance the light of the sun would be diminished $4\frac{1}{4}$ trillion times, and any star beyond this limit, which appears to us brighter than this, must be larger or more luminous than the sun. The star which, so far as our present knowledge extends, is nearest of all is that called α in the constellation of the *Centaur*, a conspicuous object in the southern hemisphere of about one-quarter the brilliancy of Sirius. A series of observations by Sir J. Herschel gave the amount of light received from α *Centauri* as $\frac{1}{27400}$ that of the full moon. The light of the full moon is not far from $\frac{1}{618000}$ that of the sun.* Hence that of the star would be about $\frac{1}{17000000000}$th that of the sun. But its distance is about 224,000 times as great, so that our sun seen from thence would have its

* The ratio between the light of the full moon and that of the sun has been a subject of investigation for more than a century; but in the various errors of assumption and the remarkable inaccuracies of method there almost seem to have been a sort of fatality. One observer compared the sun, north of the equator, with the moon when only 10° or 11° high; another compared the two with Bengal lights, the brightness of which varied during the combustion, and was unequal in different instances, etc., etc. The true ratio seems now well established through the researches of Prof. Zöllner, of Leipzig, who has attained closely accordant results by the employment of different methods.—See EULER, *Mém. Acad.*, *Berlin*, 1750, p. 299; MICHELL, *Phil. Trans.*, 1767, p. 234; WOLLASTON, *Ibid*, 1829, p. 20; BONGUER, *Traite d'Optique*, p. 85; BOND, *Mem. Amer. Acad.*, VIII., 297; ZOLLNER, *Photometr. Untersuchungen*, *and Astr. Nachrichten*, LXVI., 229.

light reduced to less than $\frac{1}{50000000000}$th part, whence we see the real amount of light emitted by this star must be about three times that of our sun, and if we suppose the luminosity of the surface to be the same in each case, its volume must be more than 11 times as great.

So, too, with the bright star α *Lyra*, in our own hemisphere, which has been employed by many astronomers as a standard of brightness. From this Struve* obtained 0·262″ as the parallax, but subsequent measures by Peters† resulted in a value of only 0·103″. The former gives 790,000, the latter about 2,000,000 astronomical units as the distance. Then for the brightness, the measures of Prof. Seidel give‡ one thirty-billionth of the sun's as the highest limit; but Mr. A. Clark has made other determinations from which he infers§ that it must exceed one eleven-billionth. Now, taking the lowest value for its light, and the least value for its distance, we have its real light as 21 times, while the other limits would make it 360 times that of the sun. Probably 35 or 40 would represent its true value pretty closely, corresponding to a bulk 200 to 250 times as great. Again similar determinations for Sirius and Capella make the light of the former to be 112 and 315 times, and of the latter about 36 times that of the sun.

But, on the other hand, we find several of those stars whose distances have been determined, to be intrinsically less luminous than the sun; so that the general impression among astronomers is that our sun holds a middle place in the scale of magnitudes, and is neither very much smaller nor very much larger than the average.

(To be continued.)

Turkey Red.—V. Wartha.—The author announces that the brilliant red color known by this name, is brought about by a union of alizarine with a fatty acid, and that this compound is soluble in a mixture of ligroine, (light petroleum oil,) and ether, by which it can readily be removed from the cloth. On evaporation, a scarlet colored fatty substance remains behind, which does not show the characteristic reactions for alizarine until after fusion with caustic potassa.

* *Additamentum in Mensuras Micrometricas*, p. 28.

† Peters, *Recueil des Memoirs des Astr. de Poulkova*, I., 136.

‡ *Monum. Saec. der Bayerischen Akad*, 1859, p. 56.

§ *Mem. Amer. Acad. Arts and Sciences*, VIII., 569.

NOTES ON CRYSTALLOGRAPHY.

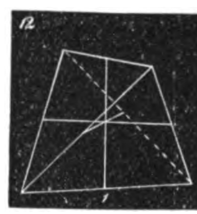
By W. H. Wahl.

(Continued from page 89.)

Holohedral and Hemihedral Forms.—It would seem, at first thought, that for a given position of the faces of a crystal, measured upon the axes, only one invariable form, with a fixed number, and one kind of faces could be produced; but, in reality, with the same facial relations to the axes, it happens that several different forms exist, one of which, however, has only one-half or one-quarter as many faces as another. Hence the use of the terms Holohedral (whole), Hemihedral (half), and Tetartohedral (quarter) forms.

If the conditions of a face to the axes are supposed to be given, the *Holohedral* form would be the one which would fulfil the given conditions by laying about the axial cross and completely occupying the space about it, the greatest possible number of planes. The *Hemihedral* form would fulfil the conditions with half as many, and the *Tetartohedral* form with quarter as many planes as the holohedral.

In some of the hemihedral forms, the peculiarity is presented, that opposite parts do not terminate equally, a solid angle, for example, being opposite a face. In others the rule holds good, which obtains for all the holohedral forms, that for every face, edge or solid angle, another face, edge or solid angle exists, similar and opposite. The forms of the first kind are termed *inclined;* those of the second, *parallel* hemihedrons. The relation of the hemihedrons to the holohedral forms, the mode of their origin, &c., will appear in the discussion of the forms themselves.



Simple and Modified Forms.—It has been said that the faces of a crystal were similar in kind and in axial position, and that hence a formula for one face would express the conditions of the whole form.

Many crystals, however, in fact the majority of them, have two or three, and often more kinds of faces, and a momentary examination shows that each of these dissimilar faces cuts the axes in different distances than the others, so that the expression for one face

would by no means answer for all. But if *one set* of similar faces be chosen, to the exclusion of the dissimilar ones, and these similar faces be imagined to be extended in all directions, there will generally result a completely closed form, composed entirely of similar faces, to which the statement fully applies, that the formula for one face expresses the relation of the whole form. From another set of similar faces, by similar treatment, another form would result to which the statement would, in like manner, fully apply: and so from each set of similar faces remaining, other and different forms can be obtained, each of which meets fully the requirements of the statement.

From this it appears that *one* crystal may be composed of a union of *two*, *three*, *or even more* different forms, and hence the distinction between what are called simple and combined forms.

A simple form is one composed entirely of similar faces, all having the same position with reference to the axes.

A combination or modified form is composed of two or more kinds of faces, each of which kind has a different position to the the axes.

It will readily be seen that all the forms taking part in a combination, being built upon the same axial cross, must belong to the same system, for the classification into systems, as has already been hinted, is founded upon differences in the axial cross. It follows, therefore, that forms with different axial crosses—that is, forms of different systems, are incapable of combining with one another. Founding his definition upon this fact, one of the ablest crystallographers* calls a crystal system "an assemblage of all the simple forms built in obedience to the same law of symmetry, and capable of combining with one another, and of the modified forms or combinations resulting therefrom."

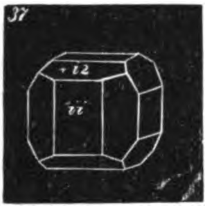
In these combinations the faces of some one form are generally larger and more prominent than those of others, and determine the *habitus* of the crystal. On this account, in writing the formula for a combination, that of the predominant form is written first, while those of the lesser forms follow in their order. The predominant form is often called the primary, the inferior ones the secondary forms.

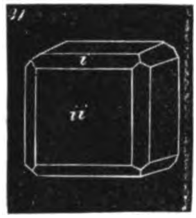
Upon a simple form, the presence of another would make itself visible, as an alteration of the edges or solid angles, and a variety

* Professor Kopp.

of terms are in use to express the kind of this alteration; for example:

An edge or solid angle is said to be *Replaced*, [37] when its place is supplied by one or more secondary faces. Such replacement





becomes *Truncation*, [31] when the replacing face is inclined at equal angles to the adjacent primary faces. An edge is said to be *bevelled*, [27] when its place is supplied by two secondary faces, each of which is equally inclined to its adjacent primary face.

An important law, underlying the combinations of simple forms is, that whenever an alteration occurs upon any portion of a crystal, for example, the replacement of an edge, this replacement must occur upon *all* or *half* the similar edges. The value of this law, in fixing the system of a crystal, will appear hereafter.

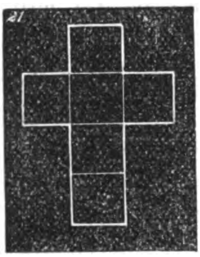
Models.—In beginning the study of the systems, it is of the greatest value to the student to keep constantly in mind the particular law of symmetry which pervades all the forms included under it. To this end it is to be recommended, that in opening a system, its axial cross be always before him, in its proper position. Rods of wood, or of glass, fastened to a support, answer the purpose fully. In order that the peculiarities of each system may be better illustrated, it is well to give to like axes some one particular color, and to to each unlike axis a different one.

Moreover, it is, in many cases, an impossibility for one to provide himself with anything approximating to a comple collection of natural crystals; and even where this difficulty does not exist, many of these are so small, and where they have grown up from some support, as many crystallized minerals occur, so imperfect that the beginner would find the greatest difficulty in comprehending their differences. On these accounts the use of models for pre-

paratory study is a matter of necessity, as they are free from the frequent incompleteness of natural crystals, and can, moreover, be had of convenient size.

They can be purchased of various materials, or, better, can be made by the student himself, with little trouble, compared with the benefit that will thereby be derived in perfect conceptions and familiarity with the subject. A good *modus operandi* is the following: A pattern of one face (of any crystal that may be needed) should be made of some appropriate material, and the proper number of faces marked out with it on stiff pasteboard, each one being joined to its neighbor, as would be the case if the faces of the real crystal were imagined so spread out. The outlines of the form—(*i. e.*, only the outer edges) are now to be cut out; the lines formed by the meeting of two adjacent faces are to be cut *half through*, so as to admit of bending; the form is to be bent into proper position, and the free edges glued together.

Fig. 21 shows the cube with its six faces in juxtaposition. The outline to be cut entirely out, is indicated by heavier lines. The lighter lines, in the interior of the field, are those which are to be cut only half through. The bending of the form until the opposing parts meet, will bring it into proper position, and glue or some other material can be employed to retain it permanently. This, though one of the simplest examples, will, it is hoped, serve to indicate clearly the process of model-making; with the more complicated simple forms, and, with the combinations, much necessarily depends upon the ingenuity of the maker. Practice, however, at this work will soon enable one to make the most difficult combinations. The pasteboard frame may then be covered with glazed paper. It will enhance the beauty of the models, as well as illustrate the properties of the forms and systems better, if colored paper is used, and if to each simple form in a system a different color be appropriated, so that in the combinations, each simple form taking part in them, shall receive the color already adopted for it.



These exercises with the models will prepare one admirably for the work of reading real crystals, which will be found a comparatively easy task.

Measurement of Angles.—In the determination of a crystal, it

is often of value to know the angle at which two adjacent faces are inclined (the interfacial angle). For this purpose Hauy's goniometer answers for all ordinary needs. The construction and use of the instrument are so simple that an explanation is hardly necessary. The instrument is held perpendicularly upon the edge formed by faces in question; the fixed arm is placed exactly upon one of the faces, and the movable one turned until it lies full upon the other; the position of the movable arm upon the scale above, gives the desired angle.

With these preliminary considerations, the step may be taken to the description of the systems of crystallography.

(To be continued.)

ABSOLUTE SYSTEM OF ELECTRICAL MEASUREMENTS.

BY JOSIAH P. COOKE, JR.

(Continued from page 204.)

11. *Electrical Resistance Expressed by a Velocity.*

ONE of the most striking results of this investigation, is that indicated by the value obtained for R, which shows that electrical resistance on the electro-magnetic system, is expressed by a velocity. The same result may be reached in another way, which will render the relation indicated more intelligible.

A current, C, in a straight conductor, of length L, crossing the lines of force of a magnetic field of the intensity S, at right angles, will experience the same force, F, as if all the points of the conductor were at the unit distance from a pole of the strength S. (See definition of unit pole and intensity of magnetic field, remembering that the action must be reciprocal between conductor and magnet). The force exerted by the conductor on a pole, S, equals, as we have seen, [5] S L C (since $k = 1$). Hence an equal force is exerted by the magnet on the conductor; or

$$F = S\,L\,C \quad . \quad . \quad . \quad . \qquad [11]$$

Let us, now, imagine a conducting wire to move perpendicular to lines of force and to its own length. We know, by experiment, that under these circumstances, assuming that the force ends of the conductor are connected with the earth, a current is developed in the circuit. The action of the magnetic forces on this current de-

termines a resistance to the motion. This resistance is of course represented by [11].

If the motion is uniform, of velocity V, the work done in overcoming resistance in *the unit of time*, will, of course, be

$$W = F\,V = V\,S\,L\,C.$$

The work produces no other effect than the current, and must, therefore, be equal to the work done by the current itself in the conductor. This work by [3] is equal to $C^2\,R$, and hence

$$V\,S\,L\,C = C^2\,R, \quad \text{or}$$

$$R = \frac{V\,S\,L}{C}, \qquad . \quad . \quad . \quad . \qquad [12]$$

When $C = S\,L$, then $R = V$, that is, the value of R in electro-magnetic units is equal to the velocity with which the conductor must be moved in the magnetic field, in order that the strength of current generated shall be equal to the product of the length of the conductor into the intensity of the field; or, more simply, the resistance of a circuit is the velocity with which a conductor of unit length must move across a magnetic field of unit intensity, in order to generate a unit current.

Moreover, it can be shown that this result is independent of the magnitudes of the fundamental units to which the various values are ultimately referred, and hence that electrical resistance is measured by an absolute velocity in nature quite independently of the units of time and space in which it is expressed.

By combining [1] with [12] we easily obtain

$$E = V\,S\,L, \qquad . \quad . \quad . \quad . \qquad [13]$$

that is to say, the electro-motive force (or difference of tension) between two ends of a conductor moving under conditions stated, is equal to the product of the length of the conductor into the intensity of the field and the velocity of the motion, or more simply, the unit length of conductor, moving with unit velocity in a magnetic field of unit intensity (as above,) will produce a unit of electro-motive force between its two ends.

12. *Determination of the Unit of Resistance.*

It is obvious that the principles of the last section give us a second method of determining the electro-magnetic unit of resistance. The unit of resistance will be obviously a wire of such length that,

when moved with unit velocity in a magnetic field of unit strength, will generate a unit current. The experiment of moving a straight wire under the conditions assumed, would be impracticable; but, by calculation, we can pass from this simple case to the more complex one of a circular coil of known dimensions, revolving with a known velocity in a magnetic field of known intensity. Weber, from these elements, determined the absolute resistance of many wires, but this method requires the intensity of the magnetic field to be known, and the determination of this element is laborious, and its value at any one place on the earth is very inconstant. But a similar method, due to Sir W. Thompson, in which a knowledge of this element is rendered unnecessary, was employed by a committee of the British Association in determining the value of the Ohm, the B. A. unit of resistance.

In the plan of Sir W. Thompson, a small magnet screened from the effect of the air, is hung at the centre of a revolving coil. By calculation it can be shown that, when the coil revolves around a vertical axis, the couple exerted on a magnetic needle of the moment $m\ l$, when deflected to the angle d, will be

$$\text{Couple} = \frac{\text{L}^2\ \text{V}\ \text{H}}{4\ \text{K}^2\ \text{R}}\ m\ l \cos.\ d.$$

The equal and opposite couple exerted by the earth's magnetism, will be

$$\text{Couple} = \text{H}\ m\ l \sin.\ d.$$

Hence,

$$\text{R} = \frac{\text{L}^2\ \text{V}}{4\ \text{K}^2 \tan g.\ d} \quad . \quad . \quad . \quad [14]$$

an equation from which the earth's magnetic force and the moment of the suspended magnet have been eliminated, and by which the absolute resistance can be calculated in terms of the several magnitudes of the parts of the apparatus employed.

For a description of the apparatus and mode of experimenting, see report of B. A. Committee, in the Report of British Association for 1863. The value obtained in these experiments for the coil actually used was 107,620,116 metres per second, and from this it was not difficult to construct the material ohm of 10^7 metre seconds.

Electrostatic System.

13. *Quantity of Electricity.*—As we have no knowledge of the essence of this agent, the term quantity, as applied to electricity,

conveys merely the idea of a relation between unknown magnitudes. In the electro-magnetic system of measurements we assume that the strength of current is proportional to its magnetic effects, and the definition of quantity immediately follows from that of current. In the electrostatic system we start from a wholly different class of phenomena, and define quantity in a different way.

As is well known, two electrified bodies attract or repel each other according as they are *charged* with the same, or different kinds of electricity. The quantity of the *charge* is assumed to be proportional to this mechanical effect, other conditions being equal, and since, if two bodies, each charged with a given quantity of electricity, are incorporated, the single body thus composed exerts an effect equal to the sum of the effects of the two, we are justifled in concluding that its charge is also equal to the sum of the charges of the two components. This fact alone justifies the use of the word quantity, as applied to electricity, which, however, we need not conceive of as a separate thing or entirely distinct from ponderable matter.

Starting from this class of phenomena, the unit quantity of electricity would be that charge which would attract or repel an equal charge at the unit distance with the unit force. The force exerted between two electrified bodies is*

$$f = \frac{q\,q^1}{d^2}, \qquad . \quad . \quad . \quad . \qquad [15]$$

where q and q^1 represent the charges and d the distance between the electrified bodies. When q an q^1 have the same signs, f is positive and the force, as we know, is repulsion. When they have different signs, f is negative and there is an attraction.

In this connection it must be remembered—

1. That when one body is charged positively, some other body or bodies must be charged negatively to the same extent.

2. That two bodies repel one another when both are charged positively or both negatively, and attract when oppositely charged.

3. That the attractive or repulsive forces are inversely proportional to the square of the distance between the electrical charges.

4. That glass, when rubbed with silk, becomes positively electrified, while resin, under the same circumstances, receives a negative

* To distinguish the electrostatic units from those of the electro-magnetic system, we shall use small letters for designating the several values in the last, while we retain the corresponding capital letters for the former.

charge. Hence, a positive charge is frequently called vitreous and a negative charge resinous.

When the two coatings of a Leyden jar are connected with the poles of a voltaic battery, that united to the inactive plate receives a positive or vitreous charge, while that united to the active plate becomes charged negatively or with resinous electricity.

14. *Ratio between Electrostatic and Electro-magnetic Measures of Quantity.*

The dimensions of q are $\frac{L^{\frac{3}{2}} M^{\frac{1}{2}}}{T}$.*

The dimensions of Q are $L^{\frac{1}{2}} M^{\frac{1}{2}}$.

The dimensions of $\frac{q}{Q}$ are $\frac{L}{T} = V$.

This ratio, therefore, is a velocity, and in order to pass from quantities measured on the electro-magnetic system to quantities measured on the statical system, we have only to multiply by this velocity, or

$$q = Q\,V. \qquad [16]$$

According to Weber's measurements, the velocity V = 310,740,000 metres per second, a velocity not differing from the estimated velocity of light more than the different determinations of the latter quantity differ from each other.

15. *Electrical Current.*—If two bodies, oppositely electrified like the two coatings of a Leyden jar when charged, are connected together by a metallic conductor, they lose, in a very short time, their peculiar properties, and assume a mutual condition. During the first moment of their junction the conductor is found to assume momentarily, qualities similar to those of a wire which unites the poles of a voltaic combination, and these effects are attributed to a current of electricity. The measure of this current is obviously the quantity of electricity, which passes per second, and hence in this system, as in the last,

$$c = \frac{q}{T}. \qquad [17]$$

* This value is derived from (5) for when $q = q^1$ we have $q\ d\sqrt{f}$. and thence

$$L\sqrt{\frac{M\ L}{T^2}} = \frac{M^{\frac{1}{2}} L^{\frac{3}{2}}}{T}$$

Hence, the dimensions of the unit of current, that is the current of a unit in quantity per second, are

$$\frac{M^{\frac{1}{2}}\,L^{\frac{3}{2}}}{T^2}.$$

Evidently, also, $c = v\,C$.

16. *Electro-motive Force.*—Whenever a current passes, or in other words, electricity is transferred from one point to another, work is done. The force that does the work, and thus effects the transfer, is called the electro-motive force. The work appears generally as heat or as magnetic power. This work must be, as before, [4] proportional to the quantity of electricity moved, and the force which moves it. Just as the work done by a falling stream of water is proportional both to the quantity of water and to the height of the fall. The first corresponds to quantity of electricity, the last to electro-motive force. Thus we have

$$W = q\,e \text{ or } e = \frac{W}{q}. \qquad . \quad . \quad . \quad . \quad . \qquad [18]$$

that is, if q units of electricity are transferred from one point to another by an electro-motive force e, the work done during the transfer will be $q\,e$, and the unit of electro-motive force is that which will do the unit work in moving the quantity of electricity between two given points.

We have already found that in the electro-magnetic system, $W = Q\,E$. Hence $q\,e = Q\,E$. But $q = V\,Q$, therefore

$$e = \frac{E}{v}, \qquad . \quad . \quad . \quad . \quad . \quad . \qquad [19]$$

Thus to reduce electro-motive force from electro-magnetic to electrostatic measure we must divide by V. The dimensions of e are then

$$\frac{L^{\frac{1}{2}}\,M^{\frac{1}{2}}}{T}$$

(To be continued.)

Powder of Chlorate of Potassa.—The experiment is now being tested by a scientific committee, in France, as to the practicability of substituting this material, partly or wholly, in place of nitre, in the manufacture of gunpowder, by mixing it with oxalic acid.

CHEMICAL TABLES ACCORDING TO THE THEORIES OF MODERN CHEMISTRY.

By Prof. Leeds.

(Continued from page 209.)

The specific gravities given in Table V. are from Boedeker (*Supplement zu den Lehrbüchern der Chemie und Mineralogie*, as quoted in Sharples' Chemical Tables). Those marked A are from the *Annuaire publié par le Bureau des Longitudes*, 1850—66: Paris. The specific gravities given in this last publication have been reprinted year after year, with few alterations and additions. A table of specific gravities, giving the temperature in every case in which reduction has not been made to 4°, or to 0° and 760 m. m., in case of gases, together with the physical condition, whether in powder, crystallized, &c., the names of the authorities and the journal or book in which the original determinations were published, is, at the present time, a great desideratum.

The molecular symbols do not attempt to represent the atomic groupings, but merely the constitution of the molecules. The numbers given in the last three columns, under the titles of molecular weights, their logarithms and arithmetical complements, will be found adequate for ordinary chemical computations.

It will be seen by comparison of Tables IV. and V. that the mol. wts. of many elements are identical with their at. wts. This may be accepted as established, with regard to zinc, cadmium and indium, but a doubt still exists concerning the other elements. To facilitate calculation, the logarithms are given for multiples of the at. wts. of the common elements.

The most frequently occurring problem in analytic chemistry will be expressed as follows:—As the log. of the mol. wt. of the body found, is to the log. of the mol. wt. of the body required, so is the log. of the weight found to the log. of the wt. required. It is evident that the result is the same whether we add together the logs. of the second and third terms of this proportion together and subtract the log. of the first term, or add its ar. co. This then reduces the problem to a simple addition. For example, we have found in an analysis ·423 grm. calcic oxide, and desire to know to what wt. of calcic carbonate it corresponds.

Log. of ·423 grm	1·62634
" calcic carbonate	2·00009
Ar. Co. of of log. of calcic oxide	8·25166
0·7554 grm. calcic carbonate	1·87819

As, however, it is not generally the absolute weights, but the per cents that are required in an analysis, it will not be essential to take out the natural number of the logarithmic sum, but merely to subtract from it the log. of the weight of the body analyzed, and the natural number of the difference will be the per cent. required.

According to the old method of calculating the formula of a compound from the found per cents of its elements, the percentage of each element was divided by its atomic weight. Thus an analysis of red silver ore affords silver 59·02, antimony 23·29, sulphur 17·49. By adding to the logs. of these numbers the ar. cos. of the logs. of the elements, we have silver, sulphur, antimony $= \cdot 546 : \cdot 546 : \cdot 192 = 3 : 3 : 1$, or $6 : 6 : 2$, and the formula might be written $Ag_6\ S_6\ Sb_2$, or $3\ Ag_2\ S + Sb_2\ S_3$.

Applying the same method of calculation to a feldspar which contains silica 64·6, alumina 18·5, and potash 16·9, we have silica, alumina, potash, $= 1{\cdot}07 : \cdot 168 : \cdot 179 = 6 : 1 : 1$. Nothing could be simpler than the process here followed, which, indeed, is identical with that in the case of red silver ore and similar compounds. But at this place we encounter a certain figment of the chemists' fancy, which has long flourished and held sway over men's minds and opinions under the name of the *oxygen ratio*. It has not a little contributed to the confusion of thought and the complexity of calculation. To take the example of the feldspar given above, the rule has been to ascertain, first, the per cent. of oxygen contained in the potash, alumina and silex., and then to find how much of these bodies are present: 2 atoms of oxygen in the silex representing one particle of silex, 3 of oxygen in alumina, one of alumina, and 1 of oxygen in potash, one of potash. Performing this calculation, we obtain for the so-called oxygen ratio of the potash, alumina and silica, $1 : 3 : 12$, and for the ratio of these three bodies themselves $1 : 1 : 6$. Thus, by a longer and more complex process, we arrive at the same result as that given above.

TABLE V.—*Molecules.*

MOLECULE.	Sp. Gr.	Molecular Symbol.	Molecular Weight.	Logarithm.	Ar. Co.
Acetic Anhydride....	2·083	$C_4 H_2 O_2$	60.	1·77815	8·22185
Acetic Acid............	3·47	$C_4 H_6 O_3$	102·	2·00860	7·99140
Aluminum............	2·67	Al	27.48	1·43902	8·56908
		Al_2	54·96	1·74005	8·25995
		Al_3	82·44	1·91614	8·08386
		Al_4	109·92	2.04108	7 95892
Alumina	4·	$Al_2 O_3$	102·96	2·01267	7·98733
Aluminic Chloride...	9 34	$Al_2 Cl_6$	267·96	2·42807	7·57193
Sulphate...	....	$Al_2 O_{12} S_6 + 18H_2 O$	664·96	2·82280	7·17720
Ammonium......... ...	....	NH_4	18·	1.25527	8·74473
Ammonia.........	0·591	NH_3	17·	1·23045	8·76955
Ammonic Oxide......	....	$(NH_4)_2 O$	52·	1.71600	8·28400
Chloride...	1·5	$NH_4 Cl$	53·5	1.72835	8·27165
Hydrate...	....	$NH_4 O H$	35·	1·54407	8·45593
Carbonate	....	$(NH_4)_2 O_3 C$	96·	1·98227	8·01993
Acid Amm. Carbon..	....	$H, (NH_4) O_3 C$	79·	1·89763	8·10237
Ammonic Oxalate....	1.5	$NH_4 O_4 C_2$	106·	2·02531	7·97469
Antimony..............	6·72 A.	Sb_4	489·36	2·68963	7·31037
Antimo. Anhydride.	6·525	$Sb_2 O_5$	324·68	2·51145	7·48855
Sulphide.	....	$Sb_2 S_5$	384·68	2 58510	7·41490
Metantimonic Acid .	....	$HO_3 Sb$	171·34	2·23386	7·76614
Pyroantimonic Acid.	....	$H_4 O_7 Sb_2$	340·68	2·53234	7·46766
Antimonous Chloride	* 7·8 A.	$Sb Cl_3$	228·84	2·35954	7·64046
Oxide....	5·566	$Sb_2 O_3$	272 68	2·43566	7·56434
Sulphide	4·752	$Sb_2 S_3$	320.68	2·50607	7·49393
Argentum (Silver)..	10·474	Ag_2	215·9	2·33425	7·99575
Argentic Chloride....	5·548	$Ag Cl$	143·45	2·15670	7·84380
Iodide.......	5 614	$Ag I$	234·95	2·37098	7·62902
Oxide.......	7·25 A.	$Ag_2 O$	231·9	2·36530	7·63460
Sulphide ...	7·2 A.	$Ag_2 S$	247·9	2·39428	7·60572
Nitrate.....	4 355	$Ag O_3 N$	169·95	2·23032	7·76968
Arsenic.........	*10·6 A. 5 75	As_4	300·	2·47712	7·52288
Acid........ ...	....	$H_3 O_4 As$	142·	2·15229	7 84770
Anhydride...	3·884	$As_2 O_5$	230·	2·36173	7·63827
Bisulphide....	3·734	$As_2 S_2$	214·	2·33041	7·66959
Tersulphide..	3·544	$As_2 S_3$	246·	2 39094	7·60906
Pentasulph...	3·48	$As_2 S_5$	310·	2·49136	7·50864
Arsenious Anhydride	* 13·85 A.	$As_2 O_3$	393·46	2·59490	7·40510
Chloride...	* 6 3 A.	$As_2 Cl_3$	181·5	2·25888	7·74112
Ammonio-magnesic.. Arsenate (Mag. mix.)	....	$(NH_4) MgO_4 As + 6H_2 O$	289·6	2·46180	7 53820
Aurum (Gold).... ...	19·34	Au_2	393·46	2·59490	7·40510
Auric Chloride........	....	$Au Cl_3$	303·23	2·48177	7·51823
Oxide...........	....	$Au_2 O_3$	499·96	2·69893	7·30107
Aurous Oxide..........	....	$Au_2 O$	409·46	2·61221	7·38779
Chloride......	....	$Au Cl$	232·23	2·36592	7·63408
Barium	1·85	Ba	137·02	2·13678	7·86322
		Ba_2	274·04	2·43781	7·56219
		Ba_3	411·06	2·61391	7·38609
		Ba_4	548·08	2·73884	7·26116

* Vapor.

TABLE V—*Continued.*

MOLECULE.	Sp. Gr.	Molecular Symbol.	Molecular Weight.	Logarithm.	Ar. Co.
Baric Chloride	3·8	$Ba\ Cl_2$	208 02	2·31810	7·68190
Oxide	4·732—5·456	$Ba\ O$	153·02	2·18475	7·81525
Hydrate	4·495	$Ba\ O_2\ H_2$	171 02	2·23305	7·76695
Peroxide	....	$Ba\ O_2$	169·02	2·22794	7·77206
Carbonate	4·3	$Ba\ O_3\ C$	197·02	2·29451	7·70549
Sulphate	4·48	$Ba\ O_4\ S$	233·02	2·36740	7·63260
Bismuth	9·78	Bi_4	841·35	2·92498	7·07502
Bismuthous Chloride	11·35	$Bi\ Cl_3$	316 84	2·50084	7·49916
Nitrate..	....	$Bi\ O_3\ (NO_2)_3 + 5H_2\ O$	486·34	2·68694	7·31306
Oxide....	8·968	$Bi_2\ O_3$	468·68	2·67087	7·32913
Sulphide	3·544	$Bi_2\ S_3$	516·68	2·71322	7·28678
Boron	2·68	B_2	22·	1·34242	8·65758
Boric Anhydride	....	$B_2\ O_3$	70·	1·84510	8·15490
Bromide	2·69	$B\ Br_3$	250·91	2·39952	7·60048
Chloride	1·35 at 7°	$B\ Cl_3$	117·5	2·07004	7·92996
Fluoride	2·37	BF_3	68·	1·83251	8·16749
Metaboric Acid..	1·83	$HO_2\ B$	44·	1·64345	8·35655
Orthoboric Acid	1·479 * 5·540 A.	$H_3\ O_3\ B$	62·	1·79239	8·20761
Bromine	3·187	Br_2	159·94	2·20400	7·79600
		Br_3	239·91	2·38005	8·61995
		Br_4	319·88	2·50498	7·49502
		Br_5	399·85	2·60190	7·39808
		Br_6	479·82	2·68108	7·31892
Cadmium	8·69	Cd	112·	2·04922	7·95078
Cadmic Oxide	8·11	$Cd\ O$	128·	2·10721	7·89279
Sulphide	4·9	$Cd\ S$	144·	2·15836	7·84164
Cæsium	....	Cs_2	266·	2·42488	7·57512
Cæsic Chloride	....	$Cs\ Cl$	168·5	2·22660	7·77340
Oxide	....	$Cs_2\ O$	282·	2·45025	7·54975
Sulphate	....	$Cs_2\ O_4\ S$	362·	2·55871	7·44129
Calcium	1·578	Ca	40·02	1·60228	8·39772
		Ca_2	80·04	1·90331	8·09669
		Ca_3	120·06	2·07940	7·92060
		Ca_4	160·08	2·20434	7·79566
Calcic Chloride	2·205	$Ca\ Cl_2$	111·02	2·04610	7·95390
Fluoride	3·01—3·25	$Ca\ F_2$	78·02	1·89221	8·10779
Oxide	3·18	$Ca\ O$	56·02	1·74834	8·25166
Hydrate	....	$Ca\ O_2\ H_2$	74·02	1·86935	8·13065
Carbonate	Aragonite 2·9 Calcite 2·72	$Ca\ O_3\ C$	100·02	2·00009	7·99991
Nitrate	2 24	$Ca\ O_2\ (NO_2)_2$	164·02	2·21489	7·78511
Oxalate	... .	$Ca\ O_4\ C_2$	128·02	2·10728	7·89272
Phosphate	....	$Ca_3\ O_8\ P_2$	310·06	2·49144	7·50856
Sulphate	2·96	$Ca\ O_4\ S$	136·02	2·13360	7·86640
Carbon	Diamond 3·5 Graphite 2·2 Coal 2·0	C	12·	1·07918	8·92082
		C_2	24·	1·38021	8·61979
		C_3	36·	1·55630	8·44370
		C_4	48·	1·68124	8·31876

* Vapor.

Table V—*Continued.*

Molecule.	Sp. Gr.	Molecular Symbol.	Molecular Weight.	Logarithm.	Ar. Co.
Carbon	....	C_5	60·	1·77815	8·22185
		C_6	72·	1·85733	8·14267
		C_7	84·	1·92428	8·07572
		C_8	96·	1·98227	8·01773
		C_9	108·	2·03342	7·96658
		C_{10}	120·	2·07918	7·92082
Carbonic Anhydride.	1·529	$C\ O_2$	44·	1·64345	8·35655
Oxide.........	0·967	$C\ O$	28·	1·44716	8·55284
Sulphide....	2·645	$C\ S_2$	76·	1·88081	8·11919
Cerium.....................	5·5 at 12°	Ce	91·33	1·96061	8·03939
Ceric Oxide.............	....	Ce O	107·33	2·03072	7·96928
Chlorine.................	2·44	Cl_2	71·	1·85126	8·14874
		Cl_3	106·5	2·02735	7·97265
		Cl_4	142·	2·15229	7·84771
		Cl_5	177·5	2·24920	7·75080
		Cl_6	213·	2·32838	7·67162
		Cl_7	248·5	2·39533	7·60467
		Cl_8	284·	2·45332	7·54668
		Cl_9	319·5	2·50447	7·49553
		Cl_{10}	355·	2·55023	7·44977
Chromium................	6·81	Cr	52·54	1·72049	8·27951
Chromous Chloride..	....	$Cr\ Cl_2$	123·54	2·09181	7·90819
Chromic Anhydride.	....	$Cr\ O_3$	100·54	2·00234	7·99766
Chloride.....	....	$Cr_2\ Cl_6$	318·08	2·50253	7·49747
Oxide.........	....	$Cr_2\ O_3$	153·08	2·18492	7·81508
Cobalt......................	8·95	Co	59·08	1·77144	8·22856
		Co_2	118·16	2·07247	7·92763
		Co_3	177·24	2·24856	7·75144
		Co_4	236·32	2·37350	7·62650
Cobaltous Chloride...	....	$Co\ Cl_2$	130·08	2·11421	7·88579
Oxide	....	Co O	75·08	1·87552	8·12448
Cobaltic Oxide..........	5·6	$Co_2\ O_3$	166·16	2·22053	7·77947
Cobaltous-cobaltic Ox	....	$Co_3\ O_4$	241·24	2·38245	7·61755
Columbium..............	....	Cb_2	196·9	2·29425	7·70575
Columbic Anhydride	4·37—4·53	$Cb_2\ O_5$	286·9	2·45773	7·54227
Chloride...	9·6	$Cb\ Cl_5$	275·95	2·44083	7·55917
Cuprum (Copper).....	8·8—9·	Cu	63·44	1·80236	8·19764
		Cu_2	126·88	2·10339	7·89661
		Cu_3	190·32	2·27945	7·72055
		Cu_4	253·76	2·40444	7·59556
Cupric Chloride.......	....	$Cu\ Cl_2$	134·44	2·12853	7·87147
Nitrate.........	....	$Cu\ O\ (NO_2)_2 + 6H_2\ O$	279·44	2·44629	7·55371
Oxide..........	6·43	Cu O	79·44	1·90004	8·09996
Sulphate Cryst	2·3	$Cu\ O_4\ S + 5H_2\ O$	249·44	2·41404	7·58596
Sulphide	4·163	Cu S	95·44	1·97973	8·02027
Cuprous Chloride.....	3·68	$Cu_2\ Cl_2$	197·88	2·29640	7·70360
Oxide.........	5·751	$Cu_2\ O$	142·88	2·15497	7·84503
Sulphide.....	5·5	$Cu_2\ S$	158·88	2·20107	7·79893
Cyanogen	1·806	$C_2\ N_2$	52·	1·71600	8·28400
		$C_4\ N_4$	104·	2·01703	7·98297
		$C_6\ N_6$	156·	2·19312	7·80688
		$C_8\ N_8$	208·	2·31806	7·68194

(To be continued.)

ON THE PHYSICO-MECHANICAL EFFECTS OF LIGHTNING.

By Prof. André Poëy.

As of all phenomena which originate in our atmosphere, those of the thunder-bolt are the most surprising, the most complicated, the most dangerous, and hitherto the least explained, every one from the savant to the most ignorant desires to know their nature and the means of protecting himself. With this object in view we have selected from an extended work, written in 1855, but still unpublished, without any addition, four of the most remarkable effects of this natural agent. No theoretical essay has been attempted up to the present on the subject, save that by Riess upon the two first phenomena. We can thus learn the intimate connection of cause and effect, existing between all the phenomena of lightning and those produced by artificial electricity. For want of space, the not less capital question of the physiological and pathological action of lightning has been omitted.

I.—*Physico-Mechanical Action of Lightning*

If we follow the series of effects produced upon wires by electrical discharges of increasing intensity, or those produced by the thunder-bolt, we find in both: 1. The wire or bar suffers a sensible molecular shock, there being formed at the same time a grey thick vapor cloud composed of metal particles detached from its surface. 2. It becomes heated and suffers inflexions, causing a shortening; in conductors stoutly stretched these are frequently supplied by a simple slight notch or by a tearing of the wire itself; this occurs with the discharge of a battery, while with the much more powerful charge of a thunder-bolt a square bar of iron with a side of 25 *millimetres* is reduced to the size of a very thin wire. 3. It becomes incandescent, softens and melts. 4. It is torn from the pincers, or separated from the points to which it was fixed. 5. It is broken into fragments, which are sometimes soldered together, without a trace of fusion at their extremities. 6. It is reduced to globules of different sizes, with or without traces of fusion. 7. And in fine, it is pulverized, and reduced to vapor.

The transformations of the wire demonstrate, that, when electricity has acquired a certain energy, it acts *thermally* as well as *mechanically*, and that neither of these two actions can be admitted to

the exclusion of the other. "Riess estimates that this double mode of action is due to the transmission of the charge being brought about in a manner altogether different, for the production of the heating of the wire, from that in which it takes place in order to cause mechanical effects, in the number of which must be placed *incandescence* and *fusion.*" "Indeed, (continues De la Rive,) it is easy to prove that incandescence and fusion are not a simple effect of the liberation of heat by the discharge, following the laws established by experiment, for this heat, the intensity of which may be calculated by knowing the force of the discharge, would be far from sufficient to produce incandescence and fusion." "What proves that pulverization is very distinct from fusion, is that tin, which requires for its fusion a smaller charge than cadmium, requires a greater, in order to its becoming pulverized." It follows, moreover, from the new experiments of M. Riess, that long before a wire begins to fuse by increasing electrical heat, it really melts, and that consequently fusion is an electric action perfectly distinct from elevation of temperature. (See De la Rive's Electricity, Walker's translation, Vol. II., pp. 253–262.)

II.—*Franklin's Cold Fusion.*

From the foregoing considerations we can now correctly draw the following conclusion: Franklin's theoretical principle, relative to the *cold fusion* of lightning, rejected afterwards by himself and the physicists, is perfectly admissible in accordance with our present knowledge upon the thermo-mechanical action of electrical discharges. Indeed, M. Riess has shown that the nature of fusion generated by discharges of a certain intensity is very different from that produced by means of fire; in short, that *incandescence*, *fusion* and *pulverization* must result from a *mechanical* and not a *thermal* effect. This is precisely what constitutes the point of departure for Franklin's principle upon *cold fusion*, when he says that lightning "creating a violent repulsion between the particles of the metal it passes through, the metal is fused *without heat;*" or by a fusion, so to speak, *mechanical.* Franklin abandoned his own ideas relative to the *cold fusion* of lightning by reason of the experiments communicated to him by Kinnersley, in which gunpowder was ignited with a brass wire reddened by the discharge of a battery. This abandonment was, however, chiefly produced by a letter of William Mountaine to Dr. Gerring Knight, in which he says that

a thunder-bolt having struck a house and melted a brass bell-chain, the remains of the chain left traces of burning on the floor. From these two observations Franklin concluded: "It is put out of all question that heat is produced by our artificial (as well as natural) electricity, and that the melting of metals in that way is not by what I formerly called a cold fusion." (See Franklin's works ed. by Sparks, 1837, Vol. V., pp. 222, 373 and 389. Also Arago's *Notice on Thunder.*)

Nevertheless, according to the experiments of Riess if the discharge of lightning has been less powerful or less rapid, the globules present no trace of pressure. It has been noticed under the microscope that they present no trace of fusion at their extremities, which are pointed as if the wire were not fused but, but broken or violently burst. On the one side, if in the celebrated case related by Franklin, the *débris* of the brass chain, reduced to globules, did burn holes in the floor; on the other, M. Riess has demonstrated that a metal chain can be reduced to little globules *without trace of fusion.* We give besides some well authenticated examples of this kind. "After the peal of thunder at Clermont-en-Beauvoisis," says Abbé Nollet, "I remember very distinctly to have seen the lead window-sashes melted in many places, the panes of glass besmoked and slate colored, *without setting fire to the wood-work,* which was broken into little splinters." After relating many of such instances Abbé Bertholon adds: "Lightning in more than twenty places which I could cite in detail, has very frequently melted iron wires without calcining the stone or igniting the wood that it traversed, etc. Those phenomena closely resemble the fusion of silver and of sword-blades without consuming the purse or scabbard containing them. Our observation must make the marvelous disappear, and show the phenomena to be more common than is generally supposed." This is now completely accomplished by the recent experiments of M. Riess and the analysis of the effects of lightning undertaken by the writer.

III.—*The Non-Inflaming of Combustible Bodies.*

To a cause purely mechanical, analogous to that of Franklin's *cold fusion*, and of other phenomena mentioned by the ancients, we must attribute very frequent occurrences of the following kind. A thunder-bolt having struck a magazine containing 800 casks of

powder, reduced two of them to *fine particles without igniting any of the powder.* (Arago, "Notice upon Thunder.") In this instance the lightning discharge acted as a dynamical force without liberating heat. Other effects analogous to the foregoing consist in its melting only the extremities of the metals traversed by it, and not heating them (in their length) sufficiently to disarrange every combustible supporting them. These results are evidently due to the instantaniety of the discharge, which produces the mechanical action of *molecular disgregation* before the molecules of the thunder-struck body have time to become heated. Fulminating powders (pyroxyline for example) has been ignited without exciting combustion in very inflammable substances (such as gunpowder) upon which it was placed and which requires, in order to take fire, the application of heat for a certain length of time. It even often happens that gun powder, when it is fine, instead of being ignited is scattered by the discharge. Hence notwithstanding the high temperature of electricity M. Ed. Becquerel could discover no trace of radiant heat—a result chiefly due as M. De la Rive has well observed, to its very great instantaniety. (See work cited II., p. 279.)

IV.—*Deflagration and Conversion to Colored Oxide of Metallic Wires.*

The appearances of colored oxidation produced by lightning and obtained immediately by discharges of a battery, or of the powerful Rhumkorff induction coil, upon stretched wires, are also *thermo-mechanical* in their nature, the chemical action of electricity playing in them its own part. These appearances have very great connection with the colored deposits of peroxide of lead obtained at the positive electrode by the decomposition of acetate of lead, with M. Nobili's colored rings, which Becquerel produced in thin sheets, and in fine, with the various shadows appearing upon polished surfaces, such as iron and steel, by the simultaneous action of heat and air. These deposits and colored rings have supplied many very fine industrial applications; for instance, the tinting exactly like nature, of *flowers* (even to the most delicate shade and smallest leaf), *birds*, etc., engraved upon metals. (For the manipulation see De la Rive's Electricity, III., p. 562.) In 1676 Father Lamy observed, wrote an account and sketched a remarkable case of the deflagration of metallic wires and their reduction to colored oxides. Whereon leather wires are stretched, lightning marked along the

wall, a species of *frieze*, the length of which was sixty centimetres. (2·36 feet). I have seen Prof. Noad produce at the *Panopticon*, London, as remarkable deflagrations with only eighteen jars. If we compare together these appearances of electricity, natural and artificial, we notice identical transversal and longitudinal vibrations, delineated by the deposit of colored oxide. The Etruscans and the ancient philosophers were without question acquainted with these deposits of metallic oxides, for they distinguished the coloring effect of lightning from its discoloring effect. The judicious Seneca, for example, makes the following remark: "It (lightning) colors or discolors objects. The difference consists in this: the discoloring alters the shade without changing it entirely; the coloring changes the color and tinges it, for instance, *blue*, *black*, *white*. (Naturalium Questionum, Liber II., Chap. XII.) For the present, at least, we will have to abandon the interesting subject, the barest outline of which is alone presented in this brief paper.

ON THE NEW CHEMICAL NOMENCLATURE.

By Dr. Adolph Ott.

(Continued from page 213.)

All the types previously enumerated may be regarded as subtypes, embraced in a regular series of types consisting of condensed molecules of hydrogen, according to the suggestion originally made by Dr. T. Sterry Hunt. In the following table, containing several new types, the condensed hydrogen molecules are connected with the types of substantially the same significance by the mathematical symbol of equivalency. Atoms in brackets in the first series are replaced by other atoms in the second.

RATIOS.	HYDROGEN MOLECULES.		OLD NAMES.	NEW NAMES.
1	: I al-[al]	$\asymp$ HCl,	Hydrochloric acid	= *alad.*
2	: I el-[el]	$\asymp$ H_2O,	Water	= *elat.*
3	: I il-[il]	$\asymp$ H_3N,	Ammonia	= *ilan.*
I	: 4 [ol]-ol	$\asymp$ CH_4,	Marsh gas	= *arol.*
I	: 5 [ul]-ul	$\asymp$ PCl_5,	Pentachloride of phosphorus	= *apud.*
I	: 6 [eal]-eal	$\asymp$ CrF_6,	Perfluoride of chromium	= *chrameaf.*
I	: 7 [eel]-eel	$\asymp$ M_nCl_7,	Perchloride of manganese	= *manamecl.*
I	: 4 [ol]-ol	$\asymp$ CH_3H,	Hydride of methyl (*achal-al*)	= *achel.*

RATIOS.	HYDROGEN MOLECULES.		OLD NAMES.	NEW NAMES.
II	: 6 [eal]-eal	=⊂⊃= C_2H_5H,	Hydride of ethyl	(*echal-al*) = *echel.*
III	: 8 [eil]-eil	=⊂⊃= C_3H_7H,	Hydride of propyl	(*ichal-al*) = *ichel.*
IV	: 10 [eul]-eul	=⊂⊃= C_4H_9H,	Hydride of butyl	(*ochal-al*) = *ochel.*
V	: 12 [yel]-yel	=⊂⊃= $C_5H_{11}H$,	Hydride of amyl	(*uchal-al*) = *uchel.*
VI	: 14 [yol]-yol	=⊂⊃= $C_6H_{13}H$,	Hydride of caproyl	(*eachal-al*) = *eachel.*
VII	: 16 [yeal]-yeal	=⊂⊃= $C_7H_{15}H$,	Hydride of œnanthyl	(*eechal-al*) = *eechel.*
VIII	: 18 [yeil]-yeil	=⊂⊃= $C_8H_{17}H$,	Hydride of capryl	(*eichal-al*) = *eichel.*
XII	: 26 [weal]-weal	=⊂⊃= $C_{12}H_{25}H$,	Hydride of lauryl	(*oichal-al*) = *oichel.*
XVI	: 34 [ixol]-ixol	=⊂⊃= $C_{16}H_{33}H$,	Hydride of cetyl	(*auchal-al*) = *auchel.*
XXVII	: 56 [uxeal]-uxeal	=⊂⊃= $C_{27}H_{55}H$,	Hydride of ceryl	(*weechal-al*) = *weechel.*
XXX	: 62 [eaxel]-eaxel	=⊂⊃= $C_{30}H_{61}H$,	Hydride of melissyl	(*weuchal-al*) = *weuchel.*

It is evident that the so-called "atomicity" does not prevent the union of atoms in a regular progressive series of ratios. In such cases, the atom-holding energy has different degrees of development as the result of the reflex influence of combination. Apparent abnormal action, for instance in the case of $I_2 \mathbf{O}_7$ *eveet*, may be accounted for by supposing an even number of atoms of oxygen, $\mathbf{O}_6$, in alternately opposite polar conditions, to be united with $I_2 \mathbf{O}$. When mercury and chlorine form calomel, *mercamad*, the anomaly is explained by the fact that the volume of the compound corresponds with that of a molecule of hydrogen; thus in this, as well as the case of the hydride of copper, *cupamal*, a dyad metal plays the part of a monad.

The new names of acids and salts, of simple as well as intricate constructions, are so framed that they may readily be resolved into syllables expressing their typical relations. This is accomplished by making the replacable hydrogen of an acid the prefix which determines the type on which the compound is constructed, as explained previously in speaking of acetic acid. The typical name of an acid or salt embraces, in fact, three terms; the first consists of the replacable hydrogen, the second is another portion of the compound of equivalence to the first, and the remaining oxygen atoms will constitute a third term having the atomic equivalence of the first and second terms combined. In chemical reactions, the second and third terms generally remain unchanged, and may therefore be included as one name, and the whole name may be said to represent the combination of a radical with a torso. Examples:

Nitric acid,	"monatomic"	[al′-anet′] at″	= *alanit.*
Sulphuric acid,	"biatomic"	[el″-aset″] et^{iv}	= *elasot.*
Phosphoric acid,	"triatomic"	[il‴-apt″]jit^{vi}	= *ilapot.*

The halogens are powerful electro-negative elements. Having the best structural adaptabiliiy, as monads, they are found among the components of many bodies. Those well investigated may be estimated in round numbers thus: Chlorides 750, iodides 320, fluorides 160, bromides 150; to which may be added another class of very similar structure, the cyanides 220: total, 1630. In this estimate, several hundred chlorhydratss, bromhydrates and iodhydrates are not included. Their new names will be so readily understood, it is only essential to present such examples as will explain the changes required by the atomic notation and the typical classification.

MONAD TYPE.

Hydrofluoric acid,	HF,	*alaf:*	Fluoride of thallium,	*Thalamaf.*
Hydrochloric acid,	HCl,	*alad:*	Chloride of sodium,	*Sodamad.*
Hydrobromic acid,	HBr,	*alab:*	Bromide of ammonium,	*Olanab.*
Hydriodic acid,	HI,	*alav:*	Iodide of potassium,	*Potamav.*
Hydrocyanic acid,	HCy,	*alarn:*	Cyanide of silver,	*Argamarn.*

DYAD TYPE.

Fluor spar,	*Calcamef.*	Corrosive sublimate,	*Mercamed.*
Chloride of thorium,	*Thoramed.*	Bromide of cadmium,	*Catameb.*
Bromide of yttrium,	*Yitrameb.*	Iodide of zinc,	*Zinamev.*
Cyanide of iron,	*Ferramern.*	Cyanide of magnesium,	*Magamern.*

TRIAD TYPE.

Fluoride of arsenic,	*Arsamif.*	Chloride of antimony,	*Stibamid.*
Bromide of gold,	*Auramib.*	Iodide of bimuth,	*Bisamiv*
Bromide of nitrogen,	*Anib.*	Solid chloride of cyanogen,	*Irnid.*
Fluoride of boron,	*Ajif.*	Bromide of boron,	*Ajib.*

TETRAD TYPE.

Perfluoride of titanium,	*Titamof.*	Perchloride of tin,	*Stannamod.*
Perbromide of tellurium,	*Tellamob.*	Periodide of platinum,	*Platamov.*
Perchloride of tantalium,	*Tenamod.*	Percyanide of palladium,	*Pallamorn.*

PENTAD TYPE.

Pentachloride of antimony,	*Stibamud.*	Quinquiodide of arsenic?	*Arsamuv.*
Pentabromide of phosphorus,	*apud.*	Quinquebromide of iodine,	*avub.*
Quinquiodide of tetraettyl of ammonium,	*echalomanuv.*		

HEXAD TYPE.

Perfluoride of vanadium,	*Vanameaf.*	Periodide of tellurium,	*Tellameav.*
Perchloride molybdenum,	*Molamead.*	Perfluoride of chromium,	*Chrameaf.*
Perbromide of tungsten,	*Wolameab.*	Perfluoride of silicon,	*Akeaf.*
Perfluoride of selenium,	*Azeaf.*	Perbromide of silicon,	*Akeab.*

SUBTYPE OF RADICAL TYPE.

Chloride of aluminium,	*Alemead.*	Perchloride of iron,	*Ferremead.*
Perchloride of cerium,	*Ceremead.*	Perfluoride of ruthenium,	*Ruthemeaf.*
Perfluoride of glucinum,	*Glucemeaf.*	Chloride of osmium,	*Osamead.*

HEPTAD TYPE.

Perchloride of manganese,	*Manameed.*	Perfluoride of manganese,	*Manameef.*

In a paper read before the American Association for the advancement of Science, at the Chicago Meeting in 1868, "On the combining power of chemical elements," Prof. Tillman premised his discussion of certain mooted questions with some observations that seem important in this connection. By the type-symbol he says, "An ideal structure of a chemical body is represented; for of the real structure nothing is known. In it the power of an atom, or a combination of atoms, is measured by degrees, the lowest power being taken as a unit of measurement. A given number of combining units require a like number to complete the structure. The new body is always the result of duality, and its form or type will be retained while its chemical function may be entirely changed by displacement; for certain parts may be removed provided a substitution of the same equivalence is made to preserve the molecular equilibrium. Thus the chemist assigns substitution values to every simple and complex radical, and designating them by numbers, from one up to six, is prepared to combine his symbols in a process of matching, which, although quite as simple as that with dominoes, affords the highest satisfaction, because it is always associated with the order, rapidity and precision of molecular changes. Yet this kind of chemical reckoning has one serious drawback, namely, the atomicity of the same element is not an invariable value. It is often decreased by a duplication of similar atoms, and in some remarkable instances among monads, it seems to be increased beyond its normal energy by a kind of induction which has not yet been accounted for.

Saturating power depends on causes and conditions still wrapt in obscurity. Equivalence involves higher questions than those of quantity and quality, as these terms are applied to ponderable matter, for two elements having diverse chemical functions and widely differing in atomic weights, like hydrogen and chlorine, sometimes assume the same relative position in the mazes of chemical combination. In many instances attractive force or affinity seems subservient to fitness of place; hence has arisen the distinction of Chemical and Mechanical or Molecular types, which can only imply that one kind of force is more effective than another in completing what may be termed the symmetry of the chemical structure."

It is not essential that the reader should examine the arguments on the variability of the saturating power of a chemical element; it is enough to know, that the doctrine of types and displacements will assist him in the further examination of the new nomenclature which adapts itself with equal facility to typical formulæ and will thus lend him additional light as he enters the domain of organic chemistry.

(To be continued.)

Bibliographical Notices.

The American Colleges and the American Public. By Professor Noah Porter, D. D., Yale College. New Haven, Conn.: Chatfield & Co., 1870.

(Concluded from page 215.)

THE suggestion, that good students of Latin and Greek will become good students of French and German after graduation, will hardly be borne out by statistics of graduates, whilst it could be anticipated with better reason, that good students in French and German in college would not throw those languages so summarily aside after graduation, but would add to them, and enjoy the rich fields of literature which they present. The philologist would doubtless add a language or two, but colleges are not for the benefit of philologists more than any other class of professional men. Most persons will admit, with the author, that Latin and Greek are more complex and difficult to acquire, though perhaps not to the degree the author claims, and consequently afford a wider field for study in their mastery. For this and other reasons they cannot, however, be fully mastered in a college course; not even those best adapted to linguistic studies can, without slighting other studies of the prescribed course, hope to acquire that familiarity with these languages that is implied by Goethe in the statement that " he knows not his own language who knows not others;" and indeed the author seems to realize that the mode of instruction in these languages generally adapted does not lead toward such familiarity. Whilst he claims the grammatical study of these languages as the " most efficient gymnastic," he admits that it is valuable mainly to those who design to teach or pursue philological studies, and he suggests, and argues his suggestion, that the disciplinary method may be profitably displaced by large " *current*" reading of easy authors—that is, reading without "dislocating" the words, or " translating them into English equivalents"—and by this method he would hope to revive "the confidence of many of our best students in classical studies," which he admits has " of late been seriously impaired." Now, there is no doubt that such thorough knowledge of any language as the author describes by ability for "current reading"—which is nothing more nor less than ability to *think* in the new language—is a most de-

sirable aim in the study of any language, and carries with it not only its own peculiar discipline, but a peculiar and elevated pleasure, opens wide the door to the literature of the language, and produces a pleasurable consciousness of new mental power, as those who have learned to think in a new language will admit. It is this kind of knowledge of a new language that Goethe alludes to. But the author here appears as the professional scholar and enthusiastic student of years, and seems to show a forgetfulness of the long and toilsome course of "painful translation," with its meagre current enjoyment, that was necessary to reach the higher plane of "current reading." To the "hopelessly dull," which in the minds of many will seem to mean those not peculiarly adapted to linguistic studies, who, about the end of the Freshman year, are not able to enter upon the new method of study, he would say: "The grammar has had its chance for you, and you have had your chance at the grammar. Let both go their own way, they must give way to something better." These students, then, with no way opened in a college course, are to be summarily cut off from college privileges, or to be dragged along in disgrace through exercises they are not prepared to profit by, and, however promising in all other respects, the author has no remedy to suggest in the way of equivalent studies. He has no allowance to make for want of peculiar aptitude for these studies, for taste, for previous training, or any idiosyncracies whatever. His own long study, and perhaps peculiar talents in this direction, have led him into an uncompromising, almost uncharitable position, towards dullards in the classics. He might indeed suppose that this were not the case, and that he simply stood upon the broad platform—that one-sided, natural inaptitude or want of taste is to be remedied by discipline, but his argument for a very low course of mathematical studies—algebra, synthetic, or ancient, geometry and trigonometry, with a hint at elective course for higher branches, rests upon the fact, that to some, by reason of "defect of capacity, or defect of early application, mathematical discipline is positively offensive." "Explain the fact as we will, the fact remains indisputable, that, to many college students, who are conscientious and diligent, the mathematics are more or less of a weariness and an offence," &c., &c. Now, the linguistic dullards might be the ones, with others, to whom these mathematical studies might not be an offence. Thorough elementary drill, or natural aptitude might make the transition from Synthetic to Analytical Geometry and

the Transcendental Analysis easy and pleasant, and enable them, without prolonged mathematical study, at least to comprehend the metaphysics of the higher mathematics, and the wonderful means of investigation they afford.

On the other hand, these students might be able to learn thoroughly, read currently, the less complex French and German, and have in these languages a post-graduate source of literary enjoyment and improvement, equal to that to be derived from as thorough a knowledge of Latin and Greek as the author proposes. The former are certainly the open doors to much more extensive and richer fields, less fragmentary, and equally humanizing in elevating literature; for not every one will be able to subscribe to the following statements of the author:

"The man of the ancient world is a different being from the man of modern life. Stately, artificial, decided, clear in his opinions, positive and outspoken in his aims, objective in his life, positive and sharp in his diction, impetuous in his impulses, grand in his connection with the state, heroic in his virtues and almost in his vices, he stands forth in striking contrast with the man of modern times—the idolatrous Pagan against the spiritual Christian, the self-cultured against the self-sacrificing, the idolater of country and the state against the worshipper of the Father and the Redeemer of man. He is always intellectual, impressive and intelligible, because he is the perfection of the natural and earthly in its purest and noblest manifestations; the man of modern life is weakened and divided—it may be by the strife of the natural with the spiritual, of passion with duty, of love with selfishness."

On the whole, the book can scarcely be deemed damaging to the cause of new education, for the author concedes that "offensiveness" of certain studies to some students is a sufficient reason for the reduction of the quantum of those studies in the course, or even for allowing an elective course, and also that, as a "most efficient gymnastic," the study of the ancient languages might with profit be confined to the first two years or less. These concessions by so ardent and able an advocate, special-pleader for the old system, will be apt to confirm the doubts of many as to the policy or justice of cramping all desirous of a liberal education into one course, and that largely made up of ancient languages, throughout the four years.

C. F. H.

Contents for October, 1870.

Illustrations—Three Plates and Ten Woodcuts.

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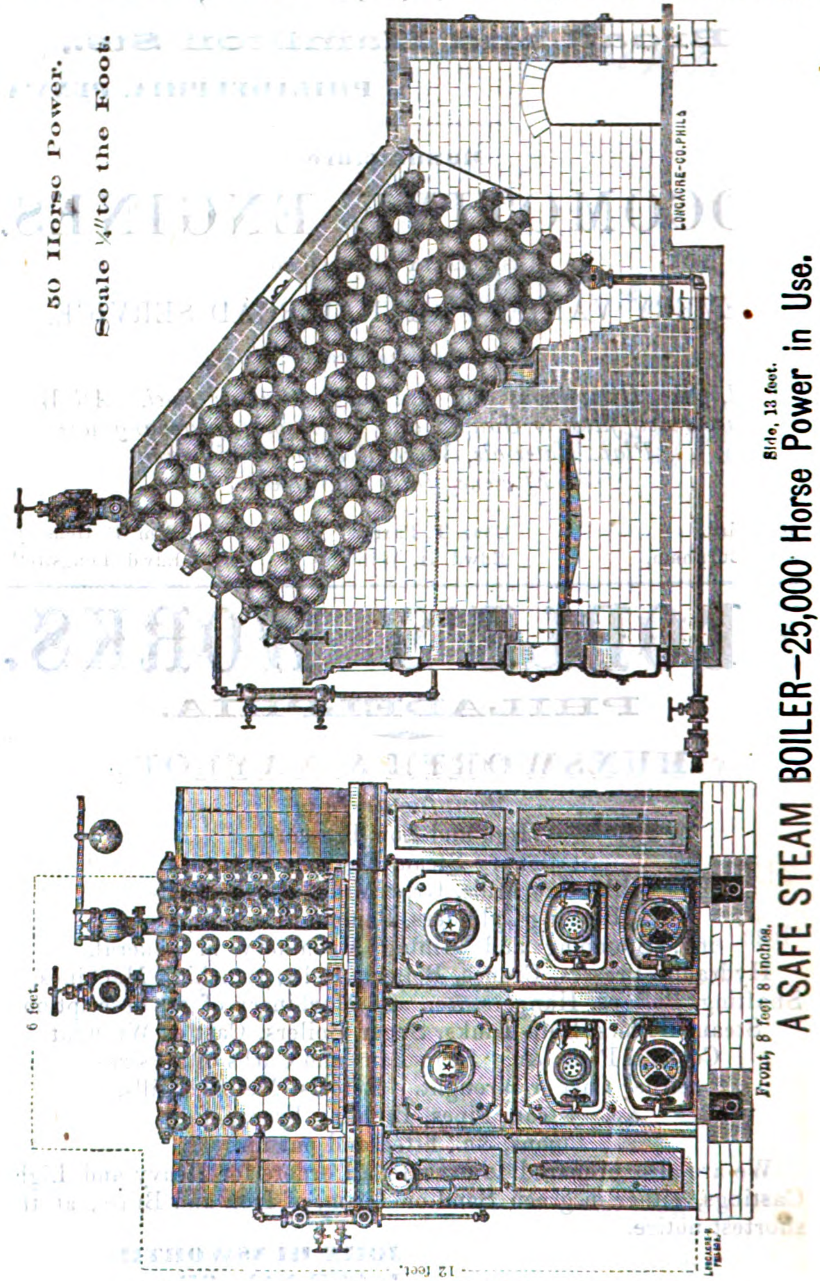

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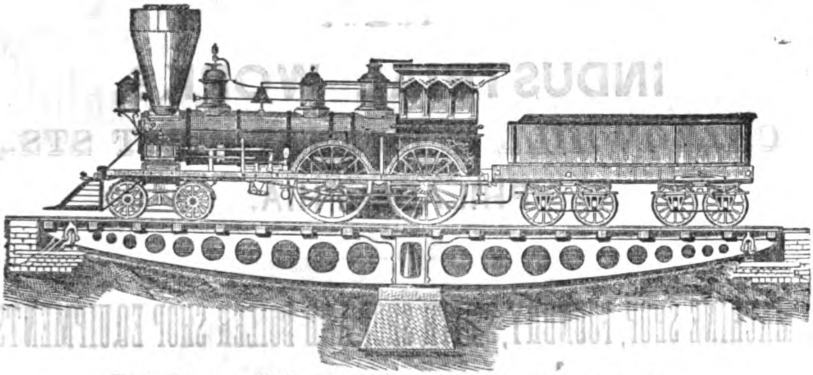

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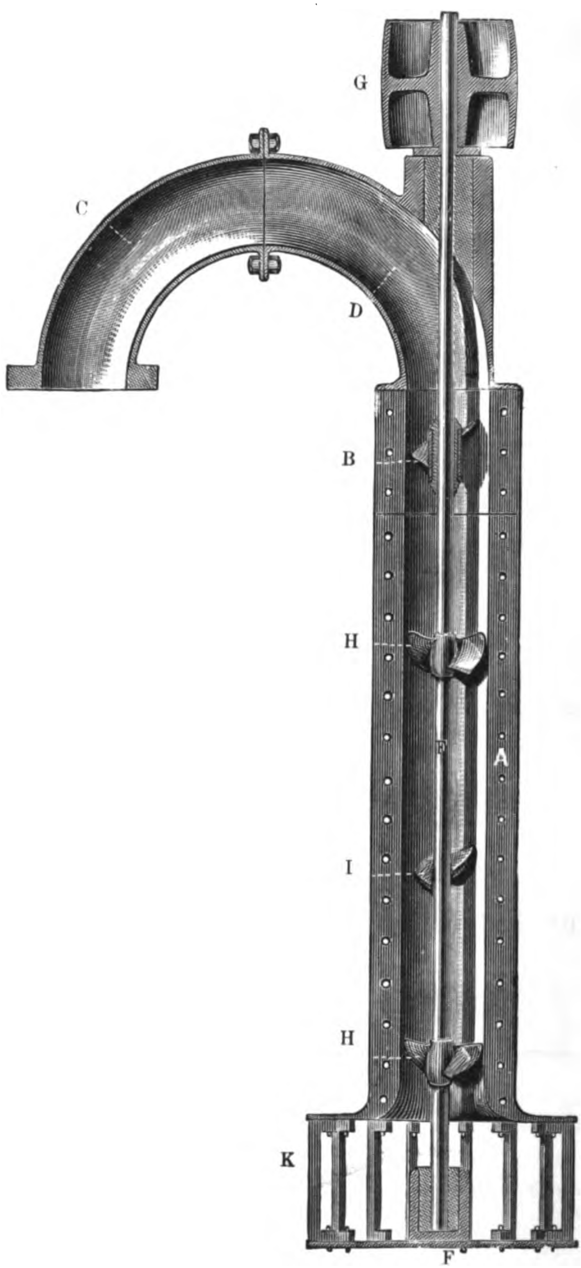

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FOR THE

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VOL. LX.] NOVEMBER, 1870. [NO. 5.

EDITORIAL.

ITEMS AND NOVELTIES

Compound Propeller Pump.—At the last meeting of the Franklin Institute, there was described and exhibited in operation a mode of elevating water, devised and patented by Mr. Thomas Shaw, of this city.

The arrangement of parts and the principle of their working will be apparent from the accompanying plate and description.

The apparatus consists of a plain pipe, A, of a bore conditioned by the quantity of water to be raised, which is furnished at intervals of every 2 feet with a short section of screw thread, I, which is cast with the pipe. The pipe is made in sections of 5 feet each in length, and is parted longitudinally into half sections, which facilitates the casting of the thread and affords great convenience in the erection or repairing of the pump. Between each of these 5 feet sections is placed a shorter pipe, B, 1 foot in length and of

similar construction, save that in the centre of each suitable provision is made for the reception of lignum-vitæ bearings. These are intended to support a shaft, F F, which passes through the centre of the pipe for its entire length. The shaft is furnished at intervals of 2 feet with a section of male screw-thread, H H, of propeller configurature located midway between the stationary threads. The bottom of the pipe is enclosed with a grating, K, to limit the size of the stones or rubbish that may enter with the water, and at the top is placed an elbow to direct the course of the water, and a bearing to resist the end thrust of the shaft. The shaft carries a pulley, G, connecting, by suitable belting, with an engine. The operation is as follows:

The water to be elevated must cover the lowest propeller blade, and upon revolving the shaft it is powerfully rotated and lifted; it continues its rotation up the stationary thread of the pipe until it comes within the influence of the second propeller blade; here a fresh velocity is imparted to it, and the lifting process is renewed precisely as it originated, until the next blade is reached, where the process is again repeated, &c.

The inventor claims for the pump, amongst other things, that it will work equally well in horizontal or vertical position; that it may be used as a fire pump by bolting the mouth and attaching hose; and that its action is unobstructed by mud, sand or rubbish, so long as sufficient water passes with the material to lubricate the bearings.

The "Captain."—The following are the particulars and dimensions of the *Captain*, whose recent loss has startled the American as well as the British public. H. B. M. S. *Captain:* designer, Capt. Cowper Coles, R. N.; builders, Messrs. Laird Brothers, Birkenhead, G. B. 1870.

Hull 320 feet long; 53 feet 8 inches beam; 24 feet 9½ inches depth. Tonnage 4,272 B. M. Plating 8, 7 and 6 inch on hull, 1 and 1½ inch on spar-deck, 10 and 9 inch on turrets, with teak backing. Forecastle and poop-decks 11 feet high, connected by hurricane-deck 24 feet wide, with iron deck-house between turrets; two 25 ton 600 pounder guns. Deck 6 feet above water. Ship rig, "tripod" masts; 33,000 square feet of canvass; fitted with 7 boats and 2 steam launches. Engines, 2 pairs trunk engines, 900 N.H.P., surface condensers; 2 screws, 16 feet diameter each. Speed on measured mile, full power 14·239 knots; half power 11,697. Com plement of officers and men, about 500. R. H. T.

The Kansas and Missouri Bridge.—A very severe and exceedingly satisfactory test was had on the 19th September of the stability of the iron columns used for the substruction of the bridge, which should be recorded.

While the submarine No. 14 was engaged taking up the anchors in the river, at a point about 100 yards above the column which has just been sunk for pier No. 1, her holdings gave way and she drifted, with the whole force of the current, broadside, against the column. Although the timbers of the boat were seriously bruised by this heavy blow, the column was not injured, and not even moved in the least.

This column now stands alone, and is not yet filled with masonry, and at the time of the accident, had a heavy barge anchored to it. If in this unfinished condition it was not affected by one of the heaviest boats on the Missouri river striking it in the manner described, some idea of the stability of these iron piers can be formed, when it is known that each pier will consist of three of these columns filled with masonry, and all firmly braced and tied together. W. W. W.

Novel Mechanical Movement.—An exceedingly ingenious substitute, which can be scarcely called a modification, of the well-known joint of Dr. Hooke, has been patented within a year by Mr. Melville Clemens, of Boston, an illustration and long description of which has been published in *Engineering*, London, September 2, 1870.

Except to a very careful reader and student this description is somewhat appalling (beside involving some errors of statement and calculation), and the drawings fail to show clearly or readily the principle on which it is constructed. In fact, the parts lie at such angles with each other, that neither drawings or perspective will convey an adequate idea of the contrivance. It gives the full range of 90° to the angle at which the shafts (in the same plane of rotation) may have, and the motion transmitted is a uniform angular one. Both of which conditions are advantages not possessed by the Hooke joint.

If it is imagined that two shafts are placed in boxes or pedestals in the same plane, but at any angle with each other from 0° to 90°, the ends of which are tee-headed and placed at such distance apart that the tee-heads will clear each other (at 90°) in rotating; and if it is further supposed that each tee-head is made the axis or knuckle of two strap or triangular hinges, and the outer extremities of the

hinges are connected (in pairs) with those which are attached to the opposite tee-head in a ball-joint, the whole forming a hinged paralellogram, the gist of the construction will be comprehended.

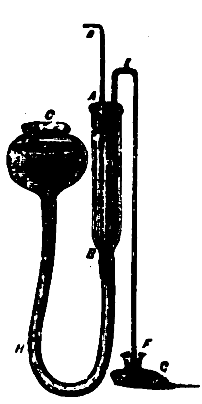
The ball-joint must allow a pestle and mortar motion of 10° to 15° and a rocking motion of 45°, and the knuckles on the tee-heads must rock 90° while the system rotates.

In a practical form for use the joints of this arrangement admit of as great strength as the Hooke joint, and the extreme range of angle to which it is applicable will render it available in many places.

The study of mechanical movements has occupied so many and so able persons, that the addition of a novel one bespeaks more than usual ingenuity; and this Clemens joint will at once take a place in the repertory of general information. R. B.

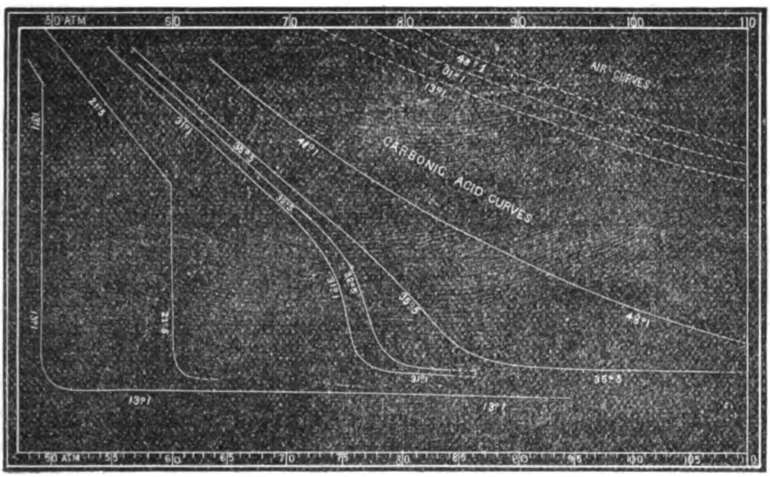
Mercurial Pump Without Valves or Stop Cocks.—We are indebted to Prof. Young, of Dartmouth College, for an account of the following ingenious arrangement which was first suggested by Mr. C. H. Smith, of Mt. Auburn Institute, Cincinnati, Ohio, to Prof. C. O. Thompson, of Worcester, Mass., and was by the latter gentleman carried out in practice with entire success.

A glass tube, A B, of such size as may be desired, is drawn out at one end, B, and by means of a stout rubber tube is connected with a mercury reservoir, C. A rubber cork at the end, A, carries two tubes, one, D, leading from the vessel to be exhausted to the bottom of A B, the other from the top of A B to a beaker, F, containing a little mercury, the height, F E, being about 30 inches.



When the reservoir, C, is raised, the mercury entering B C closes the lower end of the tube, D, and expels all the air contained in A B by the tube, H, and, in fact, is allowed to fill and flow through E F for a moment. On depressing the reservoir the mercury descends in A B and leaves a vacuum into which air flows from D; E F being over 30 inches in height, the mercury in F rises in it, but no air can enter by that way. To render the joints at A tight, a little mercury is run in over the rubber cork, as was suggested by Dr. Gibbs, of Cambridge, in his modifications of Sprengel's pump.

The Continuity of the Gaseous and Liquid States of Matter.—In a paper recently read before the "Royal Society of London," Dr. Thomas Andrews details the results of his experiments, conducted during a series of years, upon the behavior of various gases, but especially of carbonic acid gas, when subjected to varying conditions of temperature and pressure. The temperatures at which the following experiments were conducted ranged from 13·1° to 48·1° C, and the pressures from 48 to 109 atmospheres. As the object of this abstract is merely to place before our readers the main results arrived at, we will omit a description of the highly ingenious apparatus used in the work, and proceed at once to the details of the experiments themselves.



In the accompanying diagram we have the behavior of air and carbonic acid between the limits of temperature and pressure noted above, graphically represented.

The dotted lines marked air curves, show the curves of a perfect gas (supposed to have had originally the same values at the normal temperature and pressure as the carbonic acid) at the temperatures and pressures indicated. The lines marked carbonic acid curves show the volumes of this gas at the temperatures and pressures there designated. By erecting ordinates from the lower horizontal line to meet each curve at various portions of its course, the reduction in value of the gas for different stages will be indicated. An abrupt descent occurs with the carbonic acid curve at the tem-

perature of 13·1°, when the pressure of about 49 atmospheres has been reached. At the temperature of 21·5° a similar fall is seen, but not until the pressure has reached 60 atmospheres. In the remaining curves (for higher temperatures) no abruptness in the fall is visible; but as the temperature rises the steepness of the descent also diminishes, until, at a temperature of 48·1°, it has entirely disappeared. The temperature at which it ceases to present the signs of liquifaction by pressure is 30·91 C°. At this point, and at a pressure of 74 atmospheres the densities and other physical properties of gaseous and liquid carbonic acid are absolutely identical; and at this and higher temperatures the most careful examination fails to detect any differences of state, though at lower temperatures a mixture of liquid and gas would have resulted, accompanied by a more or less sudden fall or diminution of volume. This temperature (30·92° C.) Dr. Andrews calls the *critical point* of carbonic acid. Other fluids, which can be obtained in the liquid and gaseous states, have presented the same phenomenon of a critical point at a certain temperature.

From these observations the author infers that the ordinary gaseous and liquid states are simply widely separated forms of the same condition of matter, which may be made to pass, the one into the other, by gradations so gentle that the passage shall nowhere present any abruptness or breach of continuity.

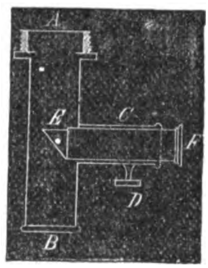
From carbonic acid as a perfect gas to carbonic acid as a perfect liquid the transition may be accomplished by a continuous process, and the gas and liquid are only distant stages of a long series of continuous changes. Under certain conditions of temperature and pressure, carbonic acid finds itself, it is true, in a state of instability, and suddenly passes, without change of pressure or temperature, but with the evolution of heat, to the condition which, by the continuous process, can only be reached by a long and circuitous route. The author discusses the question as to what is the condition or state of carbonic acid when it passes at temperatures above 31° C. from the ordinary gaseous state down to the volume of the liquid, without giving evidence during the process of the occurrence of liquifaction, and arrives at the conclusion that the answer to this question is to be found in the intimate relations which subsist between the gaseous and liquid states of matter. In the abrupt change which occurs when the gases are compressed to a certain volume at temperatures below the critical point, molecular forces

are brought into play which produce a sudden change of volume; and during this process it is easy to distinguish, by optical characters, the carbonic acid which has collapsed from that which has not changed its volume. But when the same change is effected by the continuous process, the carbonic acid passes through conditions which lie between the ordinary gaseous and liquid states, and which we have no valid grounds for referring to the one rather than to the other. Nitrous oxide, hydrochloric acid, ammonia, sulphuric ether, sulphide of carbon, all exhibited critical points when exposed under pressure to the required temperatures. The author proposes for the present arbitrary distinction between vapors and gases, to confine the term vapor to gaseous bodies at temperatures below their critical points, and which, therefore, can be liquified by pressure, so that gas and liquid may exist in the same vessel in the presence of one another.

A reliable Finder for a Spectro-telescope.—Those who have read Lieut. Herschel's account of his observations on the spectra of southern nebulæ, will remember the difficulty he experienced in his work from the very imperfect character of the finder attached to his telescope. But, even with the best instrument, the difficulty of making sure that so faint an object is correctly located with the small aperture of the finder is often great, as is proved, among other things, by the fact that mistakes have been made by the best observers, and the spectrum of a star has been observed in place of that of the nebulæ supposed to be in field.

For several years Prof. Winlock, at the Cambridge Observatory, has had in use an arrangement by which this trouble is avoided.

The adapter, A B, connecting the spectroscope with the telescope, has a tube, C, inserted at right angles, within which slides another, operated by the pinion, D, and provided with a square prism at E and eye-piece at F. Having adjusted the telescope accurately, by the use of this diagonal eye-piece, F C B, it is withdrawn by a few turns of the pinion, D, and the spectrum is then studied by means of the spectroscope. It will thus be seen that the entire power of the main telescope may be utilized both for the telescopic examination of the object



and for adjustment, while, at the same time, it is available for the spectroscope. In the first instance, of course, by means of a bright

star the coincidence of the slit of the spectroscope and intersection of cross-wires in the eye-piece, F, is established.

This arrangement may also be used with great convenience even for purely telescopic work, eye-pieces of different powers being inserted at B and F, or, as we might say, in this manner each telescope may be made its own finder.

On the Corona seen in Total Eclipses of the Sun.—By Prof. W. A. Norton.*—Certain observations made on the total eclipse of the sun of August 7, 1869, have led some of the observers to the conclusion that the corona seen on that occasion, and in previous eclipses, is of the nature of a *Solar Aurora.* It is proper that it should be publicly stated that this theory is not a new one. It has been advocated for several years by the author of the present communication, both in publications and in public lectures. It is essentially involved in the explanation of the Zodiacal Light, propounded in his treatise on Astronomy, 2d edit. (1845); and in the theoretical views set forth in a note appended to the discussion of the topic of Terrestrial Magnetism, in a memoir on Molecular Physics, published in this *Journal* (1864–6). It is distinctly presented in the last edition of the treatise on Astronomy (1867), pp. 172, 174, 175 and 178.

This introductory notice is now published mainly with the view of calling, at an early day, the attention of astronomers who may observe the eclipse of December next, to the importance of noting the exact positions, with respect to the place of the sun's equator, of the more prominent portions of the corona. From two to four points of the special outstreaming have been observed in different eclipses. In the eclipse of last year the more conspicuous extensions of the corona were nearly in the plane of the sun's equator, and from the vicinity of the poles. The figure of the corona, accompanying the report of P. Prof. Capelotti of observations on the eclipse of April 15, 1865, made at Chili, shows the same to have been the case in that eclipse. The delineations of the corona as seen in other eclipses, so far as I have been enabled to ascertain, fail to give any accurate indication of the positions of the more prominent parts from the absence of all lines of reference in the drawings. It is to be hoped that observers of subsequent eclipses will take the precaution to ascertain these positions, and note them

* Communicated by the author from the American Journal of Science and Arts, Vol. L., Sept., 1870.

in their reports. If they really have any general uniformity, in different eclipses, the fact cannot fail to throw light on the origin and nature of the corona.

Journal of the Franklin Institute.—January, 1868.—The demands for sets of the *Journal* have recently been so great as to cause a serious diminution of the stock on hand. Especially does the management feel the want of the number heading this notice. In view of this fact we are prepared to pay 50 cents for every unmutilated copy of that number which is sent to the Hall of the Institute; and we would respectfully request of any of our subscribers who may have a knowledge of the existence and whereabouts of incomplete volumes to aid us in enlarging our stock of the wanting number.

CHEMICAL ITEMS.—Artificial Populin.—It has been established by Piria that populin, by the action of acids and alkalies, attended by the abstraction of water, can be broken up into salicin and benzoic acid, and that it is to be regarded, therefore, as benzoyl-salicin, $C_{13}H_{17}(C_7H_5O)O_7$. The exhibition of a rational formula for populin is consequently conditioned upon such a formula for salicin. The latter is broken up by dilute acids, with the separation of water, into glucose and saligenin. Glucose is now generally regarded as the first aldehyde of mannite,

$$C_6H_8(OH)_6,\ \text{mannite,}\qquad C_6H_7\left\{\begin{matrix}O\\(OH)_5\end{matrix}\right.,\ \text{glucose,}$$

and the formula $C_6H_4\left\{\begin{matrix}OH\\CH_2\,.\,OH\end{matrix}\right.$ is that generally received for saligenin. Glucose and saligenin, accordingly, can be linked together to form salicin, in one of the following ways:

$$\text{I.}\quad\begin{matrix}C_6H_7\left\{\begin{matrix}O\\(HO)_4\end{matrix}\right.\\ O\\ C_6H_4\left\{\begin{matrix}\\(CH_2\,.\,OH)\end{matrix}\right.\end{matrix}\qquad\text{II.}\quad\left.\begin{matrix}C_6H_7\left\{\begin{matrix}O\\(OH)_4\end{matrix}\right.\\ \\ C_6H_4\left\{\begin{matrix}CH_2\\(OH)\end{matrix}\right.\end{matrix}\right\}O$$

Salicin, as Piria shows, can be converted into a substance (helicin) which is related to salicin, as salicylaldehyde to saligenin. Salicylaldehyde has the formula $C_6H_4\left\{\begin{matrix}HO\\CHO\end{matrix}\right.$ The salicyl factor of the salicin can, therefore, whilst it is still united with the glucose, lose two atoms of H, one of which belongs to the hydroxyl of the group $(CH_2\,.\,HO)$, and this H atom, therefore, cannot be

used in the linking with glucose. The formula (I.), therefore, is to be ascribed to salicin.

With regard to the formula of populin, we come to the question, whether the benzoyl replaces the H in the hydroxyl of the salicyl factor or in one of the glucose hydroxyls? This question is decided by the fact that populin can be converted into benzoyl-helicin. The above argument can be employed here also, and shows that populin still contains the alcoholic group ($C\,H_2\,.\,H\,O$). Therefore, benzoyl takes the place of H in the glucose factor of the salicin, and the formula of populin accordingly is:

$$
\begin{array}{ll}
C_6\,H_7 & \left\{ \begin{array}{l} O \\ (H\,O)_3 \\ O\,.\,C_7\,H_5\,O \end{array} \right. \\
 & \;\;O \\
C_6\,H_4 & \left\{ \begin{array}{l} \\ C\,H_2\,H\,O. \end{array} \right.
\end{array}
$$

Artificial populin (monobenzosalicin) can be prepared by the long-continued action, at a moderate temperature, of a great excess of benzoyl chloride upon salicin. From the resultant mixture the excess of salicin is removed by ether, the benzoyl chloride decomposed by repeated addition of water, and the benzoic acid crystallized out. The residue evaporated to dryness, dried at 100°, and treated with absolute ether, which removes the remainder of benzoic acid, leaves a white crystalline residue of populin et al. The tetrabenzolsalicin is dissolved out of this residue by ether, and the dibenzosalicin is separated from the monobenzosalicin by water. The natural and artificial populin are identical in chemical and physical properties, solubility in water included. The crystallizability, solubility in water and bitterness of taste, rapidly diminish in proceeding from salicin to tetrabenzosalicin. Dibenzosalicin is hardly soluble in water, and the bitter taste, which, in populin, is already much decreased, has quite disappeared.

$$
\text{Dibenzosalicin,}\;\left\{ \begin{array}{ll}
C_6\,H_7 & \left\{ \begin{array}{l} O \\ (H\,O)_2 \\ (O\,C_7\,H_5\,O)_2 \end{array} \right. \\
 & \;\;O \\
C_6\,H_4 & \left\{ \begin{array}{l} \\ C\,H_2\,.\,H\,O. \end{array} \right.
\end{array} \right. = C_{27}\,H_{26}\,O_9.
$$

$$
\text{Tetrabenzosalicin,}\;\left\{ \begin{array}{ll}
C_6\,H_7 & \left\{ \begin{array}{l} O \\ (O\,.\,C_7\,H_5\,O_4), \end{array} \right. \\
 & \;\;O \\
C_6\,H_4 & \left\{ \begin{array}{l} \\ (C\,H_2\,.\,H\,O \end{array} \right.
\end{array} \right. = C_{41}\,H_{34}\,O_{11} \qquad [3.]
$$

is uncrystallizable, tasteless, and insoluble in water. By similar treatment, acetyl chloride and salicin yield

$$\text{Tetracetosalicin,}\quad \begin{matrix} C_6\,H_7 \left\{ \begin{matrix} O \\ (O\,.\,C_2\,H_3\,O)_4 \end{matrix} \right. \\ O \\ C_6\,H_4 \left\{ \; CH_2\,.\,H\,O, \right. \end{matrix} = C_{21}\,H_{36}\,O_{11},$$

which crystallizes in colorless shining needles of very weakly bitter taste, hardly soluble in water, slightly in ether and in cold alcohol, very soluble in boiling alcohol. Tetratosalicin has quite the same percentage composition as salicin:

Salicin, $C_{13}\,H_{18}\,O_7$. Tetracebosalicin, $C_{21}\,H_{26}\,O_{11}$.

	Salicin	Tetracebosalicin
Carbon	54·6	55 5
Hydrogen	6·3	5·7
Oxygen	39·1	38 8
	100 0	100·0

The proximate analysis gives, therefore, no sufficiently sure explanation of the constitution. A direct determination of the number of incorporated acetyl radicals must be resorted to, and to this end the tetracetosalicin must be decomposed by strong bases. The amount of basic acetate thus formed gives the amount of primitive acetyl. Magnesia was found to answer better than the caustic alkalies, alkaline earths or plumbic oxide, for this purpose; and in the solution which had been filtered off from the excess of magnesia, the magnesia was determined as pyrophosphate. The quantity of magnesia thus obtained corresponded to 4 atoms of acetyl, and the formula, as written, may therefore be taken as correct.

Monochlorosalicin deports itself towards chloracetyl in the same way as salicin does, and yields.

$$\text{Tetracetochlorsalicin,} \left\{ \begin{matrix} C_6\,H_7 \left\{ \begin{matrix} O \\ (O\,.\,C_2\,H_2\,O)_4 \end{matrix} \right. \\ O \\ C_6\,H_3 \left\{ \; CH_2\,.\,H\,O. \right. \end{matrix} \right. = C_{21}\,H_{25}\,Cl\,O.$$

The place of the Cl atom is determined by the fact that chlorsalicin, on decomposition, yields chlorsalygenin, which may pass over into chlorsalicylaldehyde. A. R. L.

Gun-Cotton Exploded by Camphor Vapor.—Artificial Ivory.—At the last meeting of the Chemical Section of the Lyceum of Natural History in New York, Prof. Chas. A. Seely related a curious experiment which he had just tried. He pre-

faced his description by remarking that, as was well known, negative gun-cotton, or that used by photographers and others for the production of collodion, was soluble in an alcoholic solution of camphor. As alcohol had no solvent power on this substance, it was evident that this effect must be due to the camphor; and this consideration had led to the mechanical mingling by trituration of wet gun-cotton with solid camphor, which resulted in the production of an artificial ivory of the most admirable quality. In fact, billiard-balls, produced by submitting the above mixture to hydraulic pressure, and then coating with a compound of gun-cotton and castor-oil, were pronounced by experts to be superior to the natural ivory.

From the above facts, Prof. Seely was led to experiment on the influence of camphor vapor on gun-cotton.

Placing some fragments of camphor in a test-tube, and closing its upper end with a plug of gun-cotton, the tube was then set in a water-bath with the anticipation of finding some effect, discernible with the microscope, perhaps, in the course of a few hours.

Before many minutes, however, the tube was observed to be filled with red vapors; and then the gun-cotton exploded with a violence which led to the belief that if the experiment were repeated with a drachm or so of the cotton, it would be attended with danger to the operator.

This suggests the possibility of some risk in the manufacture of the artificial ivory before-mentioned, and leads to a query as to what may be the behavior of the same substance when exposed to an elevated temperature or when brought into contact with an ignited body.

The *Chemical News* conatins the following from foreign sources.

Iron by Electrolysis.—Dr. Klein.—From this paper, we derive the singular information that the iron obtained by electrolysis is not, as has generally been believed by chemists, the pure metal; but, that on the contrary, it is a compound or mixture of iron with hydrogen, which gives up an enormous quantity of that gas upon being heated to redness; and which, while greatly increasing in bulk, becomes of a silvery whiteness, very soft, ductile and malleable. It oxidizes itself energetically, decomposing water readily below its boiling point.

Fixing of Lead-Pencil, Charcoal and Chalk Drawings.—W. Wolanek.—The author states that when the paper containing

drawings or writings made with lead-pencil, charcoal, &c., is painted over on the reverse side (where no writing or drawing exists) with a moderately strong solution of bleached shellac in alcohol, the same becomes thoroughly fixed, so that they cannot be rubbed off.

The Cause of the Precipitation of Muddy Matter from water by the aid of dilute saline solutions has been investigated by Dr. Ch. Schlasing. Water otherwise pure, but contaminated simply with clay (as may be the case with the water of rivers after heavy rain or fall of snow), becomes at once clarified by very minute quantities of some salts of lime: $\frac{1}{1000}$th part of chloride of calcium for 1 part of water effects this purpose in a moment; the nitrate, bicarbonate, and caustic lime act in the same manner. The precipitated substance may be readily separated from the water by filtration, whereas the filtration of the water containing the suspended matter is very difficult, because the pores of the filters become choked. The practical importance of this matter is very great, since it is, for instance, a well-known fact that the waters of some rivers (the Durance being notorious in this respect) does not, in winter time, and after heavy rainfall or snow-storms, become quite clear, even if left at rest in large ponds for a considerable time. The same is the case with the water of the Rhine, which in its lower course is often turbid for weeks together, simply from the effects of very finely-divided clay being suspended even after the water has been at rest in tanks. The water of the river Durance supplies Marseilles with fresh water, the latter being brought to that city by a magnificent series of works, among which may be mentioned the celebrated Aqueduc de Roquefavour. Certain bitter vegetable substances have been applied in Egypt and India, for the purpose of rendering the waters of the Nile, Ganges, Indus, and other large rivers, potable, many centuries before the *rationale* of the action of these substances was understood.

Picric Acid and Ozone.—The Abbé Moigno has recorded that when Picric acid is introduced into a vessel containing ozone, a violent detonation instantaneously takes place, a new proof of the danger attending experiments with nitrogenous compounds containing nitrogen only loosely bound.

Poisoning by Aniline Dyeing.—A. Dollfus.—The author states that while two of his workmen were engaged in dyeing cotton-yarn in a hot mixture consisting of aniline, hydrochloric and tartaric acids, sulphuret of copper, chlorate of potassa and water, the men were suddenly siezed with severe headache, difficult respiration, tremor and languor, becoming cold and very weak. Properly administered medical aid restored them to health; but the author cannot account for these alarming symptoms otherwise than by assuming them to be due to the volatilization of some chloride of arsenic, which may have been formed in consequence of some arsenic having been left in the aniline by careless manufacture unless, indeed, the symptoms are due to the action of the vapors of aniline itself.

Oxy-Calcium Light applied to Photo-Micrography.—We have received from Col. J. J. Woodward, U. S. A., some excellent pictures, with powers as high as one thousand diameters, from the oxy-calcium light as the source of illumination, which are in no respect inferior in quality to photographs of similar objects taken with the magnesium lamp. The success of the Colonel's experiments are of no slight importance in view of the fact that the oxy-calcium light possesses peculiar advantages over both the electric and magnesium lamps, amongst which are to be reckoned the comparative cheapness of the light, simplicity of the apparatus for running it, and its superior steadiness.

Editorial Correspondence.

A LABORATORY FOR CHEMICAL RESEARCH.

Dr. W. H. Wahl.

Dear Sir:—In a recent number of the *Revue des Duex Mondes* will be found an article by an eminent French author, containing, among a number of other comparisons, all favorable to Germany, one relating to the laboratories of Prussia and of France.

The writer earnestly calls the attention of his countrymen to the great superiority of the *German* Universities respecting their facilities for theoretical investigation and practical application in the departments of Physics and Chemistry. He dwells especially upon the great Friedrich Wilhelm Laboratory at Berlin, recently completed at a cost of a million and a half of francs, and of the similar

laboratory at Bonn, which cost a half million of francs. The former, under the charge of the illustrious chemist, Prof. Hofmann, more resembles in its external appearance, in its lengthy corridors, frescoed halls and spacious lecture-room, some museum devoted to art, than the dingy accommodations which were long thought adequate to the wants of chemists.

The laboratory of the Ecole des Mines impressed me the most favorably of those which I saw in Paris. It is restricted, however, to metallurgical operations. But the laboratories of the Ecole Polytechnique, of the Jardin des Plantes, the antiquated and dismal apartments of the Ecole Centrale, and even the newly-erected addition to the Sorbonne, are much inferior in the facilities offered to those of Berlin. And the practical effect of this inferiority is manifest in the relative condition of the Physical Sciences in the two countries.

A great French chemist begins a philosophical treatise, recently published, with the declaration that "Chemistry is a French science." But the greater bulk and importance of the contributions which have been and are being made to chemistry by German authors sufficiently disprove this arrogant assumption. And, moreover, the fact that German, rather than French, is becoming the general language of science upon the continent, is evidence of the most convincing kind. Not many years ago the proceedings of the Royal Academy at Berlin were published in the latter language; now, this and all other contributions from Prussia are in German.

Of late years the importance of these studies has so deeply impressed the public mind in some portions of our own country, that the course of collegiate and academic instruction has been revolutionized. As, for example, at Cambridge, where the capacities of the college laboratory are at present being enlarged to such an extent as to accommodate eighty students with desks and all the paraphernalia of manipulation. Their course is intended to combine the practical with the philosophical in such a way as not only to enable the students to *do* but to *think*. They commence at once with manipulatory chemistry, using for the purpose the elaborate treatise of President Elliot and Prof. Storer. Then the students enter upon the study of the admirable *Chemical Philosophy* recently published by Prof. Cooke, which taxes their thinking powers quite as much, perhaps, as Hamilton's or Mill's Logic. At the same

time they attend a series of chemical lectures, and finally enter upon a course of analysis. Likewise, a special laboratory is provided, where, during the last twelve years, a number of investigations have been made by young American chemists, which are highly creditable to our national scholarship, and have been recognized as such abroad.

A similar institution is now being organized at Hoboken under the presidency of Prof. Morton, and supported by the munificent bequest of nearly three-quarters of a million of dollars, which was made by the late Mr. Stevens. The student will find there several spacious laboratories for investigations in Physics and Chemistry. These will be provided with every appliance which the exactitude and intricacy of modern science demand; and the student who has mastered previously-acquired knowledge in these departments may pass to the glorious work of solving new problems and exploring what is yet as land unknown.

I do not wish herein to detract from the excellence of the instruction imparted in our own city at the University and in our Medical and Dental Colleges. So far as lecturing and text-books can give a knowledge of Physical Sciences these institutions do admirably, and the courses of lectures delivered by their eminent professors are worthy of the highest praise. Neither do I desire to say anything which is not of the most favorable character with regard to the few colleges and private laboratories where facilities for a practical knowledge of qualitative and quantitative analysis and of metallurgy are afforded. But I wished to draw attention to the fact that a city which once stood foremost in this country in point of scientific activity, and which is now perhaps the largest producer of chemical wares, has at the present time no general laboratory at all adequate to the wants of investigators in the Physical Sciences. I think I am representing the feeling of a large number of students clustered around the Academy of Natural Sciences, the Franklin Institute, the Philosophical Society, and our various colleges, in saying that any movement upon the part of our public institutions, or any act of private munificence which would give the students in Philadelphia as fair a chance for researches in physiology, physics and chemistry as are enjoyed by those of Berlin or Cambridge, would meet with the deepest gratitude, and would, in itself, result most beneficially to the higher interests of this great manufacturing city.

ALBERT R. LEEDS.

Civil and Mechanical Engineering.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 238.)

Planing Machines.

Under the general title of planing machines may be classed all that are used for reducing or shaping wood with rotary or fixed cutters: "planing" being a term generally used to define wood cutting, both in the United States and in Europe. In this country, however, the term is applied only to cutting straight lines, while in England it is common to hear it applied to operations that are here denominated turning.

Mr. Molesworth, of the Institute of Civil Engineers, London, in a paper read before that body on wood conversion, in 1857, refers to concentric turning machines as "socket planes," a term, no doubt, as correct as our own. Custom has, however, established the conventional term, "planer," to machines for lumber dressing, that is, bringing rough stuff to true dimensions with rectangular sections, while machines for forming molded sections are termed molding machines, and those for shaping irregular forms are termed shaping machines. These distinctions we deem both necessary and proper, and shall in these articles adhere to this classification, commencing with the dimension planing machine, which was the first type of machine employed, and is yet the most important. Planing wood, as a process, can be divided into three operations, the distinction between which is not often considered, and yet quite obvious.

Dimension planing, as we will employ the term, relates to the class of machines wherein the material is guided in straight lines to receive the action of the cutters, its course being directed by tracks or guides, which may be considered as representing, for the time, an artificial side to the material, the piece being planed and the guides being combined. The second operation we will term "guage planing," where the material is passed over fixed beds or guides,

by means of feed rolls or other mechanism, and is reduced to a parallel thickness, but the profile is regulated by the surface of the piece; that is, if the material is sufficiently flexible it leaves the machine in the same shape in which it entered, except that it will be reduced to a parallel thickness.

The third class of machines we will term "surface gauging planes," wherein the material is guided by the same surface that is acted upon by the cutters, a constant amount being cut away at all points without in any other manner changing the dimensions or shape of the material. The most important of this kind of planers, in fact the only one that has ever come into general use, is of American origin, and will, in the course of these articles, be illustrated and described.

The first machine entitled to the name of wood planing machine, of which we have any record, has already been alluded to in connection with the account of General Bentham. It was invented by him while in Russia, in or about 1780, *ninety years ago.* This machine, as previously stated, we have reason to suppose was the one described in his patent of 1791, and consisted in travelling cutters, guided with parallel movements over the face of the lumber. To show the acquaintance of Bentham with the laws of force and mechanism, we will quote from his specification as follows. Speaking of the motive power, he says: "By brute force I mean not only the strength of animals, but the force of inanimate objects, such as wind, water, steam, &c., and even that of men when employed in such a way as to require neither skill nor dexterity on the part of the person who executes it. By this means, machines may take the place of human skill in this operation (planing) to as perfect a degree as in any of the manufactures on which invention has been employed, so much to the honor and advantage of this country. Hence arise three capital advantages: first, the quantity of force used at one time may be increased at pleasure: second, the force of men may even be exerted in this way to a greater advantage than while confined, as in the present practice, to a particular mode *by the necessity of care and dexterity:* third, the labor of the awkward and unpracticed may be called in," &c.

We quote this to show the logical reasoning of the inventor, and that he went about his invention with a definite object, working with such data as were at hand to produce a power planing machine for wood. This first machine was, most likely, only made in an

experimental way; for in his patent of 1793 (two years later), he seemed to have got hold of the idea of rotary cutters. Dating the rotary cutting plane from this time, we will notice, first:

Dimension Planing Machines.

Under this head, as before explained, will be classed all machines that give shape to the stuff by means of independent guides, as distinguished from machines wherein the stuff is guided by its own surface or outline.

To the dimension planing class belongs what is popularly known as the Daniels' planer, or, more properly, "transverse" planer, for if it is to be distinguished by the name of our inventor, that distinction belongs to "Bramah," whose patent bears date of 1802. His invention is often alluded to as the Bramah wheel, but it is broad and comprehensive, describing all the leading elements of a modern Daniels' planer. In the introduction to his specification, which was very elaborate, even for that time, when the inventor relied mainly on his specification, he says: "I mean to use and apply for the purposes stated every kind of edge tool or cutter already known, either in their present shape or with such variations and improvements as the variety of operations I may encounter will severally call for; but the tools, instead of being applied by hand, as usual, I fix as my judgment may direct, on frames, driven by machinery, some of which frames I move in a rotary direction around an upright shaft, others with the shaft in a horizontal position. I cause the material meant to be wrought to slide in contact with the tools," &c. The specification fills 11 pages in the Repertory of Patent Inventions, describing the cone feed-gears that are now so commonly used to regulate the changes of feed for engine lathes, also the fluid bearing for shafts that has been very recently patented again. From the description, however, there is no evidence of his having suspended the frame, or cutter head, so as to use its whole diameter as in the modern planer, an improvement that gave the name of "Daniels" to the machine.

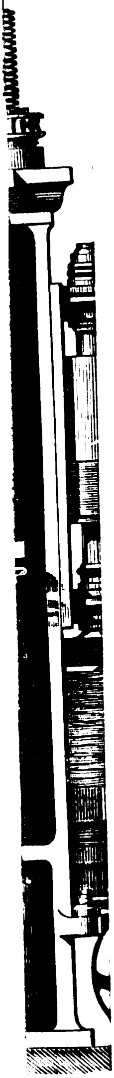
Transverse describes the action of the machine where the cut is across the fibre. The wood is more easily displaced by cutting in this manner; besides, tools that would be too dull to act longitudinally will work well across the fibre, which is severed transversely in the one case, but removed by a kind of wedge-action in the other. To explain it by a more familiar operation, the wood is *split off* by

the transverse planer, and were it not for the lighter resistance offered to the cutters in these machines, it would be impossible to hold the material without forcing it out of its normal shape, by clamping devices. This action of cutters across the wood, from their high velocity and easy operation, allows most kinds of heavy framing to be planed without clamping to the carriage, being held only by its weight. When we see a transverse planer removing a larger amount of wood in a given time than a roller machine, with apparently no disturbing strain on the piece, it presents a problem worth studying—the roller machine, provided, say with 6 feet of cutting edge (three-knife cylinder on a board 24 inches wide), working with the fiber; the other, with about two inches, or one-thirty-sixth part as much cutting edge, doing as much work, by cutting across the fiber. We say it presents a problem, one of those that must be thoroughly solved and thoroughly understood before we can expect any fixed rules of construction or any standard form and arrangement of planing machines.

The Daniels' or transverse planer is used in nearly all wood shops in the United States. Its peculiar adaptation to dressing framing and rough lumber, with the exercise of but little skill on the part of the operator, and its cheapness, recommends it.

The shafts, being some of them vertical and others horizontal, precludes anything like a compact framing, which has led to the angular modern "crib arrangement," that has not been much varied from, in twenty years past. Recent improvements in wood machinery, and the demand for stronger and more durable machines, have led to designs with iron framing, which present many advantages.

The illustration (Fig. 1), from the designs of the manufacturers, Messrs. Allen Ransome & Co., of London, England, represents a machine of this class. The engraving is a true side elevation, ½ inch to 1 foot. The cutter head is a solid disk, containing several tubular and smoothing cutters. The entire machine is carefully fitted, and can be driven at a high speed on the roughest work. The weight is from four to eight tons, according to the length. Richards, Kelley & Co., of Philadelphia, manufacture transverse planers on the same general plan, with iron framing. The table or carriage is made of wood; the extension track is formed of wrought iron rails, that can be adjusted vertically or laterally, to keep the track in line. The feeding mechanism and cutter heads are also of



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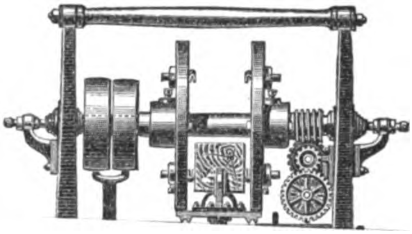
and improved construction. An engraving of these machines will be furnished in a future number.

English planers of this kind are generally short, and built with iron carriages, but in our American shops, where the stuff to be dressed is often forty, and not unfrequently fifty feet long, such a table would be out of the question. A table or carriage of iron, of these proportions, would be too heavy to reverse or handle.

Fig. 1.



ERRATA.

(WOOD-WORKING MACHINERY.)

The reference to Figure on page 308 should be to *Plate*; and on page 310, the reference should be to *Figure* 1.

[illegible]
riage on a broad flat track, with guiding shoulders at right angles with their faces.

The small amount of cutting edge that can be used on transverse planing machines is one of those unfortunate conditions sometimes met with in the construction of machines, that baffles the inventor, and necessitates the compromise of doing the best thing possible to meet them, and enduring the rest. In removing wood by transverse cutting, the fibers have not only to be wedged or split off, but severed across their section. To do this the cutting tool must have a curved edge, or stand in an angular position with reference to the face of the lumber. The feed must be regulated by the pitch of

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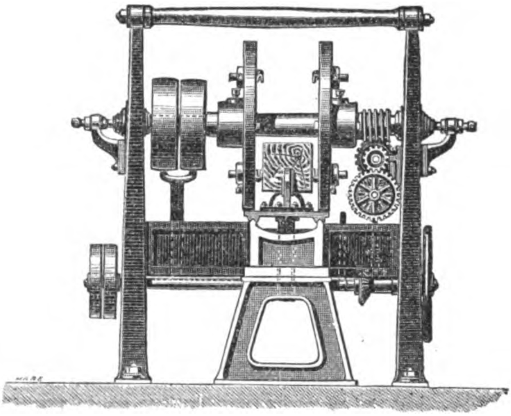
Fig. 1.



The best carriages for these machines are made by glueing up very dry lumber, to prevent warping; pine boards, with a facing of ash or cherry, make a good carriage. The track bearings should be made with a sufficient surface to prevent wear and the consequent irregularity in the top of the table. A V-track for these machines is unnecessary and objectionable; the cutting being done in a horizontal plane, it is obvious that any slight lateral movement in the table will not affect the work, and it is better to run the carriage on a broad flat track, with guiding shoulders at right angles with their faces.

The small amount of cutting edge that can be used on transverse planing machines is one of those unfortunate conditions sometimes met with in the construction of machines, that baffles the inventor, and necessitates the compromise of doing the best thing possible to meet them, and enduring the rest. In removing wood by transverse cutting, the fibers have not only to be wedged or split off, but severed across their section. To do this the cutting tool must have a curved edge, or stand in an angular position with reference to the face of the lumber. The feed must be regulated by the pitch of

these cuts across the fibre, so that no width of cutting edge is needed behind the lip or angle of the tool, and the practice is to use on these machines only gouge point tools, two in number, making the cutting edge as stated in a former place, but a fraction of that which can be applied on a cylinder plane. It is true that to multiply the number of edges, this trouble might be overcome, if there were no practical objections to such a plan ; but the trouble of setting even four cutters, to work on the same plane, involves time and care, and when we consider how often they have to be removed and changed, it is quite impossible to accomplish the object by this means. Perhaps the nearest approach to securing wearing capacity in the cutters of these machines is the "Wilson Tubular Cutter," consisting of a hollow cylinder of tempered steel, ground to an edge at one end, and so arranged in its bed as to be partially rotated as soon as it becomes dull at one point. This gives the equivalent of the curved gouge-cutter, and a length of edge corresponding to the length of its inner circumference. A cylindrical cutter of this form, with a bore 1½ inches diameter, gives a cutting edge of about 4¾ inches, which can be divided into, say, ten parts, so that one guiding and setting accomplishes as much as the guiding and setting of the common cutter ten times, if we do not count the time of adjusting the tubular cutter, which is but little if it is provided with annular guiding grooves to prevent its shifting endwise. These cutters (Wilson's patent) serve an admirable purpose for light planing, for joiner and furniture work, &c., but in reducing rough ship or other heavy timber on the heavier class of machines, the chips are too large to pass through the tubes, and the angular cutter with a curved edge is to be preferred. Fig. 2 is an end elevation of a scantling planing machine, as manufactured by Messrs. A. Ransome & Co. It is intended for squaring up framing of all kinds, from one to eight inches square. The timber either rests upon the face of the carriage, or if turned in any part, can be held on centres. The feed shown on left of the engraving can be varied by change gearing. This machine can be applied to a large range of work, such as dressing the felloes of wheels, the squares on bed posts, table legs, &c. It is simply a compound transverse planing machine, to work both sides of such timber as is sufficiently stiff in its cross section to be supported at the ends only.

(To be continued.)

THE PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Jos. M. Wilson, C. E.,

[P. A. Engineer, Construction Department, Pennsylvania Railroad.]

The Pennsylvania Railroad Company possess large Constructive and Repair Shops on their main line at West Philadelphia, Harrisburg, Altoona, and Pittsburgh. Those at Altoona are the most extensive, having grown up with the road from its commencement; and it is at this point that the heaviest work is done. The West Philadelphia shops, although considerably smaller, attract much interest, however, as probably showing the best general arrangement and details of construction of any owned by the Company, since they have been designed as a whole, and all built within the last eight years. With this view, we hope the following description of these shops will not prove unacceptable.

Plate 1 gives the Eastern part of the West Philadelphia yard, showing not only the position and grouping of the new shops proper, but also the arrangement of all the tracks, the passenger depots, offices, and other buildings belonging to the Company at this point. Those marked from 1 to 18 inclusive comprise the new shops; and it is only these that we propose describing in detail. This yard, including a portion not shown here, contains $4\frac{3328}{5280}$ miles of single track in main line, and 22 miles in sidings and shop tracks, making a total of $26\frac{3328}{5280}$ miles of single track. It has a double track connection over Market Street Bridge with the freight depots of the Company, situated on the east side of the Schuylkill river, also a connection, via Delaware Extension of Pennsylvania Railroad, with a grain elevator and coal wharves on the Delaware river, the City Gas Works at Point Breeze, and the Philadelphia, Wilmington and Baltimore Railroad. In a portion of the yard west of Bridge street and not shown on plan, it has a connection, via Junction Railroad, with the Philadelphia and Reading Railroad, and via Connecting Railway, with the Philadelphia and Trenton Railroad, to New York. Thus it will be seen that the facilities for transfer, and running of through trains, are very great. The grade crossing at Bridge street, now the only one in the yard, will shortly be superseded by an overhead bridge, doing away with a source of danger to the public, and allowing of uninterrupted movement of trains.

The group of buildings marked 22 and 23 consist of a locomotive house and machine shop, built some years ago, when this part of

the road belonged to the State, and do not merit attention. The Grain Depot, No. 29, has been but recently erected, and is for the accommodation of the city or local trade only. A full description of this building was given in the *Journal of the Franklin Institute*, Vol. LIX, p. 17. The bridge, by which the six tracks from the Grain Depot cross over Thirtieth street, has also been described previously. (See *Journal Franklin Institute*, Vol. LIX, p. 198.) The office buildings, Nos. 27 and 28, are occupied by that portion of the transportation department managing the Philadelphia division of the road. The passenger depot buildings are only temporary, and in the course of time it is expected that a large, commodious depot will be erected, containing all the requisite comforts and conveniences for the proper transaction of business and the needs of the travelling public. The gas supply house, No. 32, is a small building, containing an engine and pump for the compressing of illuminating gas, obtained from the city works, into receivers, for lighting of passenger cars.

Having given a general outline of the more important matters of interest connected with the location of the new shop buildings, we will now proceed to take up each building in order as numbered in table of references, Plate 1, and describe it in detail.

Locomotive House.—The locomotive house is a regular polygon in form, of forty-four sides, having an inner, open court, in the centre of which is a turn-table. From this table diverge forty-four tracks, thus affording accommodation to that number of locomotives. Plate II shows a plan of one-fourth of the building. Considering the house divided into forty-four stalls, one for each track, as these stalls are all similar, advantage is taken of this in the plan to show a different stage of the work in each stall. Thus we have successively, the foundations, the same with wall plates laid, the floor joist, a stall floored over, &c., &c. On Plate III are given details of various parts of the building.

Fig. 1 is a vertical section through turn-table pit and building.

Fig. 2 shows a panel of outside wall, one-half representing part of an entrance door and the other half a window.

Fig. 3 shows a panel of the inside front and the door for same.

Fig. 4 gives inside and outside heel blocks of roof truss.

Fig. 5 shows details of cast iron inner front.

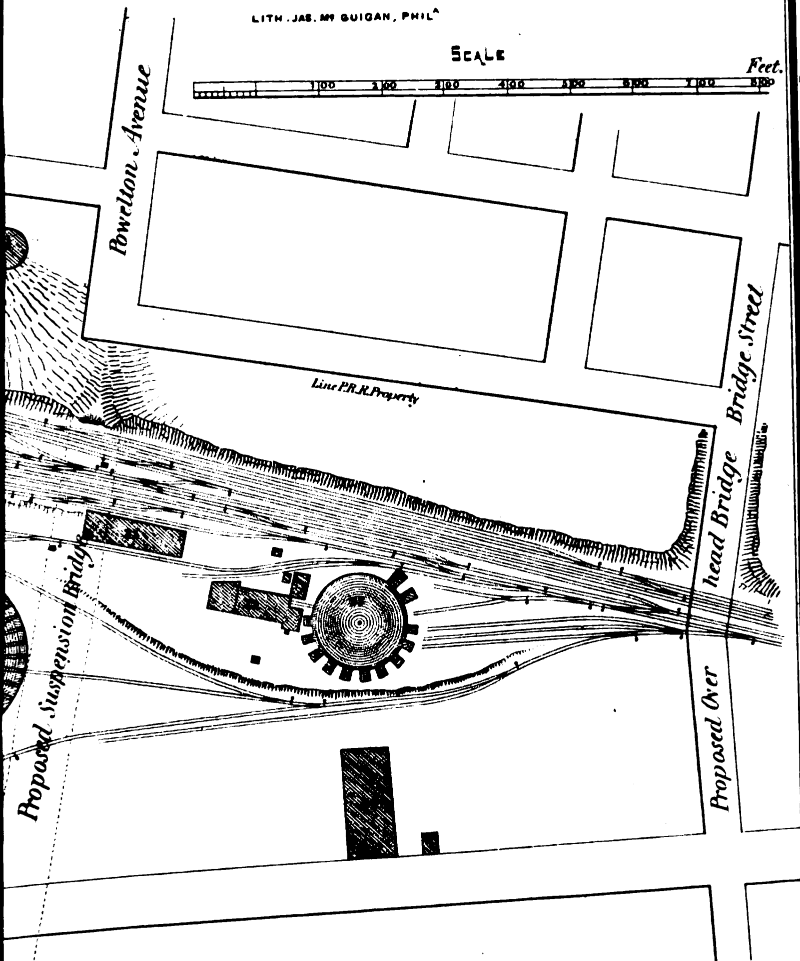
Fig. 6 is a cross section through a pit in one of the stalls.

Fig. 7 is a cross section through turn-table at centre, showing arrangement of rollers.

ENNSYLVANIA RAIL ROAD SHOPS

WEST PHILADELPHIA.

LITH. JAS. M^c GUIGAN, PHIL^A



References.

1 Locomotive House
2 Locomotive Shop
3 Blacksmith Shop
4 Boiler Shop
5 Store House
6 Oil House
7 Transfer Table & Pit
8 Shop Offices
9 Passenger Car Shop
10 Blacksmith Shop
11 Water Closets
12 Wood Working Machine Shop
13 Paint Shop
14 Coal Houses
15 Freight Car Repair Shop
16 Steam Pump & Well
17 Steam Pump & Well
18 Reservoir
19 Carpenter Shop
20 Stable
21 Coal Platform
22 Machine Shop
23 Locomotive House
24 Stable
25 Lumber Shed
26 Oil Shed
27 Offices Transportation Dep^t
28 " " "
29 Grain Depot
30 Pennsylvania Passenger Depot
31 New York Passenger Depot
32 Gas Supply House for Pass Cars

Construction Dep^t, Penn^a R.R.

The diameter of the building from out to out is 300 feet, and that of the inner court is 168 feet 11 inches. The clear width in the interior, from inside to outside wall, is 62 feet 10 inches, and the height, from the top of rail to the tie rod of roof truss at heel blocks, is 21 feet 9 inches. Of the forty-four tracks contained in the building, two are entrance tracks. All, except these entrance tracks, have pits 42 feet 6 inches long by 3 feet 11 inches wide, 2 feet 9 inches deep at front and 2 feet 6 inches deep at back. These pits have stone side walls 2 feet thick, and are paved with brick, laid on edge and grouted with cement. They drain into a sewer at their lower end, as shown on plan, Plate II. There is a sheet iron smoke flue for every track, placed directly over the position of the smoke stack of the locomotive when in place. Ventilators are placed in ridge of roof on every alternate stall.

The foundations of the building are of stone, the outer walls being 2 feet 6 inches thick, and all inner walls 2 feet thick. The outer wall finishes off 4 inches below the ground, and is capped with a belting course of cut stone, 9 inches by 15 inches section. All the doors, on both inner and outer fronts, have cut stone sills, 12 inches by 17 inches section, the rails of tracks being cut into these sills, so as to give a flush surface on top, and allow the doors to fit neatly and closely. The cast iron blocks, at bases of columns of inside front, rest upon cut stone blocks 2 feet square and 1 foot thick. The outer wall above the belting course is of brick, built in panels, with pilasters both inside and out, and an ornamental outside cornice, as shown, Fig. 2, Plate III. The thickness of brick in panels is 13 inches, and on pilasters 22 inches. Two of the panels are occupied by entrance doors; the balance have windows, two in each, except that there is a small door, 4 feet 8½ inches opening, in one of the panels, taking the place of a window. A flush arch is built in the wall on the inside over every pair of windows, to provide against any injury to the cornice or roof, in the event of accident to the wall below from locomotives. The entrance doors are 3½ inches thick, paneled as shown, Fig. 2, Plate III, and have a clear opening in width of 11 feet 1½ inches. They are furnished with wickets, or small doors, to allow persons going in and out easily, without opening the large doors. These doors are hung on heavy cast iron hinge blocks, built into the brick work, there being three wrought hinges to each door. The windows have 4 feet 8½ inches by 9 feet 11 inches opening in brick work, the outside sills and

lintels being of cast iron. They have box frames, and two flights of sash, six lights each, of 12-inch by 18-inch glass, and are double hung with cord, weights and pullies.

The inner front of the building is of cast iron, the metal being $\frac{7}{16}$ inch thick, except for the columns, which are $\frac{5}{8}$ inch metal. The doors have a clear opening in width of 11 feet $1\frac{1}{2}$ inches, and are 3 inches thick, paneled and glazed as shown, Fig. 3, Plate III, so as to afford an abundance of light. Three of these doors have wickets. All of the doors are provided with inside turning bars to fasten them when shut, and hooks to secure them in place when open.

The floor joist are 3-inch by 12-inch white oak, placed 15 inches apart from centre to centre for half the extent of each section, and 12 inches from centre to centre for the other half. They are cambered 1 inch at the outer wall, and proportionally less as they get shorter in approaching the inner front. The joist are laid upon 3-inch by 12-inch white oak wall plates, and they have one course of lattice bridging on the centre line of each section. The flooring is double, consisting of, first, 1-inch white pine sub-flooring, worked to a thickness and laid close, and then on this, 2-inch white pine flooring, worked, tongued and grooved. The rails are laid upon 3-inch by 12-inch white oak track stringers, cut into the floor joist, the top of stringer being laid flush with top of joist. A small gutter runs along each rail and drains into the pit, see Fig. 6, Plate III.

The roof truss is constructed on the triangular system, of wrought iron, having a space of 64 feet 6 inches from centre to centre of bolt holes in heel blocks, an inclination of rafter of $22\frac{1}{2}$ degrees from the horizontal, and a rise in tie rod in centre of span of 6 inches above a horizontal line through the extremities. The diameters of the tension rods are given on the drawing. The rafter is a 6-inch I-beam, weighing 40 pounds per yard, and the struts and heel blocks are of cast iron. The heel block on the inner front is firmly fixed to top of column; that on the outer front rests upon rollers on a cast iron bed plate, a wall plate of white oak, 4 inches by 17 inches by 5 feet long, being laid under the bed plate on the brick wall. This arrangement allows of free expansion and contraction, owing to changes of temperature. The arrangement of purlins is shown on drawing, Plate II. They are of white pine, 4 inches by 8 inches and 4 inches by 10 inches, and are secured to the rafter by a wrought iron angle piece and clip, one arm of the angle piece being bolted to the purlin, while the clip passes over the other arm and around

the upper flange of the I-beam which forms the rafter. The purlins are cambered on the external circle, and made concave on the internal circle of the roof, so as to avoid hips and valleys and allow the roof covering to be laid evenly. On the purlins is laid roof sheeting of 1-inch worked white pine boards. The sheeting is covered with the best quality slate, from the Peach Bottom quarries of Pennsylvania. On the outside roof the slate run 11 inches and 10 inches by 20 inches, laid to weather $8\frac{3}{4}$ inches, with the exception of nine courses from the ridge, which are 9 inches by 18 inches, laid to weather $7\frac{3}{4}$ inches. On the inside roof the slate are 8 inches by 16 inches, laid to weather 7 inches. Gutters of double cross roofing tin run around the eaves of inside and outside fronts, to receive the drainage from the roof. To protect this tin from the action of destroying agents in the atmosphere, it is well painted on the underside with two coats of red lead in oil, before putting on, and afterwards, on the upper side with one coat of the same, over which the finishing colors are laid. From the gutters a 4-inch eave pipe runs down the outside wall on every alternate pilaster of the brick work, discharging into a sewer which goes entirely around the building, and a 3-inch eave pipe runs down the inside front on every alternate column, between the hinges at the back, discharging by a small box drain into the pit sewer.

Water plugs, with standard hose attachment, are placed in the floor in alternate stalls, and are protected by cast iron covers level with the top of floor. These plugs are supplied by a 4-inch cast iron main pipe, passing under the floor of the building. Hydrants and wash sinks are provided at necessary points. In every section, against the outside wall, is a work bench and vise, with the necessary tools for any slight work required on the locomotive. The building is warmed in winter by large cast iron stoves, the pipes from which pass into the smoke flues already described as provided in the roof for the locomotives. To retain the heat as much as possible within the building, the stalls of the entrance tracks are separated from the balance of the house by partitions extending from the floor to the roof, and in winter the roof ventilators are closed. A small building is connected with the locomotive house, and shown on Plate I, by a projection from one of the panels, for the purpose of preparing sand for use of locomotives. It contains a large, shallow cast iron pan built over a furnace, for drying the sand, and two apartments, one for receiving it when fresh, and the other to store it when dry.

Between the locomotive house and turn-table, the rails of the track are laid on white oak cross ties, 6 inches by 8 inches, imbedded in stone ballast 14 inches deep. The turn-table, manufactured by William Sellers & Co., of Philadelphia, is 50 feet in length, and may be described as follows: A cast iron, rectangular box, resting upon a central pivot which is provided with Parry's anti-friction conical rollers, has projecting from it four cast iron, horizontal arms, in pairs, two on each side. Near their outer extremities, the arms in each pair are connected by a cast iron strut, in each end of which, on the under side, is a wheel. These wheels are suspended just above a circular track below. Upon the horizontal arms, cross ties of white oak are placed, and on these the rails of the turn table track are laid. Fig. 7, Plate III, gives a section through the central box, showing the pivot and arrangement of the anti-friction rollers. The rollers and the plates between which they work are made of steel, and are very durable. The centre pivot is placed upon an exceedingly firm stone foundation, 6 feet square, and capped with a single cut stone 5 feet 6 inches square and 1 foot 3 inches thick. The circular rail is laid upon white oak cross ties, below which is a substantial stone foundation extending out far enough to sustain a 22-inch brick wall, which surrounds the pit in which the table moves. This brick wall is capped by a white oak curb, 4-inch by 13-inch section, held in place by 1-inch anchor bolts built in the brickwork. On this curb the tracks from each stall of the building terminate. The spaces between the cross ties under the circular rail are filled in with brick laid in cement, the top surface being slightly inclined, so as to drain into the turn-table pit. The latter is paved with brick laid flat and grouted with cement. The turn-table pit drains into a main sewer which runs across, under the house, and receives the drainage from all the other sewers of the building. In each end of the table is a heavy bolt, fitting into sockets in the curb, of which there is one for each track from the building. By means of these the table can be rapidly and securely fixed for any track desired. The table is set at such a height that when fully loaded, the wheels under the arms bear very slightly on the circular track. It will be noticed that no gearing is used for moving the table, it being entirely unnecessary. When unloaded, a weight of only 1½ pounds attached to the outer end of one of the arms by means of a cord passing over a pulley, will move the table. When fully loaded with locomotive and tender, properly

balanced, the table may be readily moved by one man. He is provided with an iron bar, one end of which fits to the bolt previously spoken of. He walks along the curb, pushing by means of this bar, and when he arrives at the desired track, immediately drives the bolt home, securing the table where wanted.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 254.)

Mr. F. W. Bacon has kindly furnished me with the following: A certain 13-inch pulley on a shaft running 203 revolutions per minute carries a belt 2·25 inches wide, and drives a 20-inch pulley on a shaft 20 feet vertically above. The pulleys are smooth turned iron and the belt of single leather, with grain side to pulleys.

This belt had been running a year or more, under a tension which was limited only by the strength of the lacing. It was used to convey two horse-power to the upper shaft, but was considered by the lessee to be unequal to the task, even when tightly drawn, and its adhesion increased by free application of rosin.

It was admitted by both parties that the belt was worked to its fullest capacity.

In order to ascertain the exact amount of work done by the belt, the following experiment was made:

On the driven shaft above was a smooth turned iron pulley, 6·25 feet in circumference and 4-inch face; over this was thrown a 3-inch leather belt, with grain side to pulley, and to its ends were attached unequal weights, such that the 2·25-inch belt was subjected to its maximum working power. These weights were 203 pounds and 2·25 pounds, Speed of friction pulley was taken at 132 revolutions per minute.

Then we have $132 \times 6·25 = 825 =$ velocity of 3-inch belt in feet per minute, and $\frac{825 \times 200·75}{33,000} = 5·018 =$ horse power of 3-inch belt.

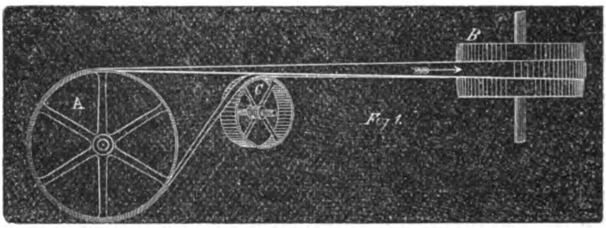
This is equivalent to a driving power of 41·1 square feet of belt per minute per horse-power.

Rule for Horse-power of a Belt, from "Overman's Mechanics," p. 414. —One example will explain the table. It is assumed that belts

should have a speed of 25 to 30 feet per second, and that a 12-inch belt on a 3-feet pulley will transmit 10 horse-power.

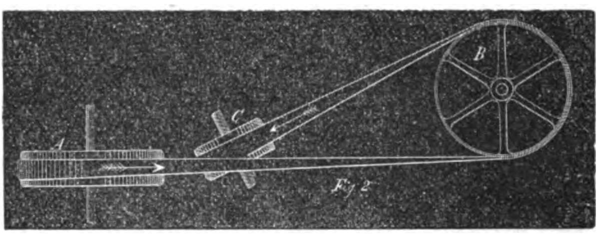
At 25 feet per second this means a surface velocity of 150 square feet per minute per horse power, which is a liberal allowance.

The quarter turn belt applied to driving mill stones or upright shafts.—A is the driving pulley on horizontal shaft. B the driven pulley on mill spindle or upright shaft. C the tightener, which is placed at the proper angle for receiving the belt from B and delivering it to A; it has a short shaft running in bearings secured to a



frame which slides vertically in fixed grooves, and may be raised to tighten the belt for driving, or lowered to slacken the belt for stopping B, at pleasure. B is made wide and straight on the face to admit of motion in raising and lowering the stones, as well as to allow of lead of belt by the different positions of C, which are due to length and tightness of belt.

A and C should be rounding on their faces. The cut shows the proper positions of the pulleys and shafts, and also gives good



working proportions, the particulars having been obtained from machinery in use.

We make a few extracts from a paper "On the centrifugal force of bands in machinery," by W. J. M. Rankine, in the *Engineer* for March 5, 1869, p. 165:

"It is well known, through practical experience, that a belt for communicating motion between two pulleys requires a greater ten-

sion to prevent it from slipping when it runs at a high, than at a low speed.

"Various suppositions have been made to account for this, such as that of the adhesion to the belt of a layer of air, which at a very high speed has not time to escape from between the belt and the pulley. But the real cause is simply the centrifugal force of the belt, which acts against its tension, and therefore slackens its grip of the pulleys.

"****** It can be proved from the elementary laws of dynamics, that if an endless band, of any figure whatsoever, runs at a given speed, the centrifugal force produces an uniform tension at each cross section of the band, equal to the weight of a piece of the band, whose length is twice the height from which a heavy body must fall, in order to acquire the velocity of the band.

"In symbols, let w be the weight of a unit of length of the band; v the speed at which it runs, and g the velocity produced by gravity in a second ($= 32{\cdot}2$ feet); then the *centrifugal tension* (as it may be called) has the following value: $\frac{wv^2}{g}$.

"The effect on the band when in motion is, that at any given point, the tension which produces pressure and friction on the pulleys, or *available tension* (as it is called), is less than the total tension by an amount equal to the centrifugal tension; for this amount is employed in compelling the particles of the band to circulate in a closed or endless path. It is, of course, to the total tension that the strength of the band is to be adapted, therefore the transverse dimensions of a band for transmitting a given force must be greater for a high than for a low speed.

"One of the most convenient ways of expressing the size of a band is by stating its weight per unit of length; for example, in pounds per running foot or in kilogrammes per metre. When the size is expressed thus, the corresponding way of expressing the intensity of any stress on the band is in lineal units of itself, such as feet or metres. Let l denote the greatest safe working tension on a band of a given kind, in units of its own length; so that $w\,l$ is the amount of the safe working tension in units of weight. Let T be the amount of the available tension required at the driving side of the band for the transmission of power, being usually from two to two and a half times the force to be transmitted. Then the total tension is

$$T + \frac{w\,v^2}{g} = w\,l.$$

Whence it is obvious that the required weight per unit of length is given by the following formula:

$$w = \frac{T}{l - \frac{v^2}{g}}.$$

"For example, suppose that the band is a wire rope, that the greatest working tension is to be equivalent to the weight of 2900 feet of the rope, and that it is to run at 100 feet per second: then we have

$$l = 2900 \text{ feet};$$

$$\frac{v^2}{g} = 310 \text{ feet};$$

And consequently the weight per running foot of the rope required is:—

$$u = \frac{T}{2900 - 310} = \frac{T}{2590};$$

Or about one-eighth part heavier than the rope required, for a speed so moderate as to make the centrifugal tension unimportant.

"In fixing the value of the greatest working tension on a wire rope, a proper deduction must of course be made for the stress produced by the bending of the wires round the pulleys.

That stress is given *in equivalent length of rope* by the expression $\frac{L\,d}{D}$, where D is the diameter of the smallest pulley round which the rope passes, d the diameter of the wire of which the rope is made, and L the modulus of elasticity of the wire, *in length of itself*, viz: about 8,000,000 feet, or 2,400,000 metres. That is to say, let l be length of the rope equivalent to the greatest safe working tension on a straight rope; l_1 as before, the length equivalent to the actual greatest working tension, then

$$l = l_1 - \frac{L\,d}{D}.$$

"In the case of leathern belts, b may be estimated at about 660 feet, or 200 metres.

"In the case of a leather belt running at the rate of 100 feet per second, the weight per unit of length required, in order to exert a given available tension, is increased in the ratio of $\frac{660}{660 - 310} = \frac{660}{350}$ or to nearly double, as compared with that of a belt whose centrifugal force is unimportant.

"The *sectional area of a leathern belt* may be calculated approximately in square inches by multiplying the weight per running

foot by 2·3; or in square millimetres, by multiplying the weight in kilogrammes to the running metre by 1000.

"The ordinary thickness of a single belt being about 0·16 inch, or 4 millimetres, the breadth may be deduced from the sectional area by dividing by that thickness.

"The length (L) equivalent to the modulus of elasticity of a leathern belt, as calculated from Bevan's experiments, is about 23,000 feet, or 7000 metres.

(To be Continued)

THE ALLEN ENGINE.

By Charles T. Porter.

(Continued from page 252.)

In an engine of 16 inches diameter of cylinder by 42 inches stroke, making 60 revolutions per minute, and in which the reciprocating parts weigh 600 pounds, the force required to impart and arrest their motion is, at the centres, only 6 pounds on the square inch of piston, diminishing to nothing at the mid-stroke. If the speed of piston is increased from 420 feet, as above, to 600 feet per minute, by employing a stroke of 5 feet, and the weight of the reciprocating parts is increased to 1200 pounds, even then the force so absorbed and given out at the centres by these parts is only 18·4 pounds on the square inch of piston.

In an Allen Engine, however, of 16 inches diameter of cylinder by 30 inches stroke, making 120 revolutions per minute, with reciprocating parts weighing 1200 pounds, the force required on the centres to impart and arrest the motion of these parts is 36·8 pounds per square inch of piston.

In the smaller engines the force required for this purpose becomes, at the same speed of piston, considerably greater even than this. In the size 6 inches diameter of cylinder by 12 inches stroke, with reciprocating parts weighing 100 pounds, it amounts on each centre to 54 pounds for each square inch of piston.

Thus in these engines this reciprocating fly-wheel, at the speed of 600 feet per minute, absorbs, at the commencement of each stroke, from 37 to 54 pounds of the force of the steam on each square inch of the piston, permitting it to become gradually effective on the crank, and gives out this force again when that of the steam

is reduced very low by expansion, preventing all shocks and equalizing the pressure on the crank throughout the stroke.

Let W = weight of reciprocating parts.

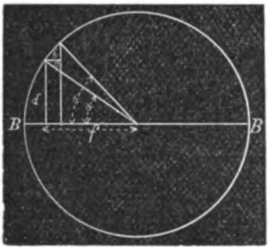
S = mean speed of piston in feet per second.

L = length of crank in feet.

a = angle of crank from centre line.

P = total mean pressure required to impart to the reciprocating parts the velocity which they have when the crank is at the angle a.

In the figure, the diameter B B represents the motion of the reciprocating parts during the stroke, while the semi-circumference of the circle represents that of the crank during the same period. As the length of the semi-circle is 1·5708 times that of the diameter, the speed of the crank must be 1·5708 the mean speed of the reciprocating parts. At half stroke, however, the velocity of these parts is the same as that of the crank pin, while at any other point the velocity bears the same proportion to that at half stroke as the sine of the angle a bears to the radius of the circle. We have then the velocity of the reciprocating parts in feet per second at any time = 1·5708 S sin. a. We know from the laws of falling bodies, that these parts, acted on simply by their own weight, W, would, in passing through a space of 16·08 feet, acquire a velocity of 32·17 feet per second, these being respectively the distance moved and velocity attained in one second. As the force required to impart any velocity to a body is directly as the square of that velocity and inversely as the distance through which the force is exerted, we may obtain from the above the mean pressure required to impart the velocity, 1·5708 S sin. a., to the reciprocating parts by the following proportion :



$$\frac{(32 \cdot 17)^2}{16 \cdot 08} : \frac{(1 \cdot 5708 \text{ S} \sin a)^2}{\text{L versin } a} : : \text{W} : \text{P},$$

$$\text{whence P} = \frac{\text{W} \cdot 0384 \text{ S}^2 \sin.^2 a}{\text{L versin } a}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

For the angle a', immediately following a, and differing from it by but an infinitesimal quantity, another value for P would be obtained entirely similar to this, which we may write:

$$\text{P}' = \frac{\text{W} \cdot 0384 \text{ S}^2 \sin.^2 a'}{\text{L versin } a'}, \quad . \quad . \quad . \quad (2.)$$

The numerators of these fractions represent the quantity of work due to their velocity, stored up in the reciprocating parts at the angles a and a' respectively, while the denominators are the distances moved through in acquiring this velocity, the quotients being the mean pressure exerted through this space to impart the velocity which they have acquired. The difference of the numerators will give us the amount of work imparted in passing from a to a', and this divided by the difference of the denominators gives the pressure required at this point to impart the acceleration to the parts. We have, then, calling this P

$$P^a = \frac{W \cdot 0384\ S^2}{L} \quad \frac{\sin.^2 a' - \sin.^2 a}{\text{versin } a' - \text{versin } a}, \quad . \quad . \quad (3.)$$

Referring to the figure, we observe, that if the sin. a is represented by d, the sin a' will be $d + b$, and the difference of their squares $2\ b\ d + b^2$. The difference of the versins is represented by c, and we have for the last factor of equation (3):

$\frac{2\ b\ d + b^2}{c} = (2\ d + b)\frac{b}{c}$. But $\frac{b}{c} = \frac{f}{d}$, and hence we may write $(2\ d + b)\ \frac{f}{d}$ which is equal to $2\ f$, since the distance b is infinitely small and the quantity $\frac{b\ f}{d}$ consequently $= 0$.

The distance f being the cosine of a, we may therefore write the above equation:

$$P^a = \frac{W \cdot 077\ S^2 \cos.\ a}{L}, \quad . \quad . \quad . \quad . \quad (4.)$$

At the commencement of the stroke, cos. $a = 1$, and the expression becomes

$\frac{W \cdot 077\ S^2}{L}$, while at half stroke it becomes 0 diminishing in direct proportion to the value of cos. a, or the proportion of the half stroke passed through.

To put this formula in the shape most convenient for use.

Let $A =$ the area of piston in square inches.

$p =$ pressure per square inch absorbed in accelerating the reciprocating parts at any point $= \frac{P^a}{A}$.

$R =$ the number of revolutions of the engine per minute.

$l =$ length of crank in inches.

We may then write for the pressure at the commencement of the stroke:

$$p = \frac{\cdot 0000285\ W\ R^2\ l}{A}, \quad . \quad . \quad . \quad . \quad (5.)$$

From the fact that L occurs in the denominator of equation (4), it follows, that for the same speed of piston, the shorter the stroke the greater the value of p, while, since it occurs in the numerator of equation (5), it follows that for the same number of revolutions per minute, the value of p will increase with the length of the stroke.

It is evident, if the foregoing be true, that the action of the reciprocating parts, as developed in this engine, is of great importance, and that a high grade of expansion ought not to be employed except in connection with it.

But action and reaction are equal. The force which puts the reciprocating parts in motion tends, in the opposite direction, to produce a recoil of the engine precisely like the recoil of a gun when a shot is discharged from it. In ordinary slow running engines, this force is so trifling that, in the one direction, it puts but very little energy into the reciprocating parts, and in the other it is quite insufficient to disturb the steadiness of the engine itself. But it increases directly as the weight of the reciprocating mass, and as the square of the rapidity with which motion is imparted to it, and thus it becomes in this engine sufficient to produce, through this mass, the useful effect already described, and just in the same degree to impel the engine itself in the opposite direction.

This statement applies, however, to horizontal engines only. In a vertical engine, the impelling force, however strong it may be, cannot produce any recoil, because it is resisted by the whole mass of the earth. But in a horizontal engine, when it is exerted in a really useful degree, if unbalanced, no amount of weight in engine-framing or foundation could resist the reaction; it would impart vibration to the ground and to the entire building in which the engine stands. This reaction is, however, completely neutralized, and the engine caused to run in absolute steadiness, by the employment of a

Counterbalance.—This is placed in the crank-disk, opposite to the crank. Its office is, first, to balance the crank itself, so that the revolving parts shall be in equilibrium, and besides this, it is made sufficient to balance the reciprocating parts also.*

* The force required, in a horizontal engine, at every point in the stroke, to impart or to arrest the motion of the reciprocating parts, is equal to the horizontal component of the centrifugal force which would be exerted by a revolving mass of the same weight, whose centre of gravity was at the centre of the crank-pin. The case is, in the horizontal direction, precisely the same as if the reciprocating parts were gathered at the centre of the crank-pin, and were revolving there. Conse-

The arrangement of this counterbalance is shown in Figure 1, Plate I. It needs to be considerable, for which reason the crank-disk is made large, and opposite to the crank, it is cast hollow, and is filled with lead. The perfect equilibrium attained contributes essentially, in addition to the effect of the inertia of the reciprocating parts, to give to this engine its smoothness of running.

Although the subject here presented is of the highest practical importance, and is to become so prominent in the near future of the steam-engine, still it is at present so little understood, that engineers will generally find it difficult to realize that the reciprocating parts of engines are, on the dead-centres, where they have been considered passively at rest, exerting a strain on the crank equal to, and identical with, the centrifugal force which they would exert if they were revolving with it, and it is to be feared that some may even be imprudent enough to deny the fact, which, however, will not be affected thereby.

(To be continued.)

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

By Col. O. W. Childs, C. E.

(Continued from page 247.)

The soil along the line, between San Juan harbor and the Juanillo, is vegetable mould, coarse sand and sandy loam; from Juanillo to dam No. 7, it is principally fine loam, with a small proportion of clay; above the latter point on the river, it is of a more mixed character, clay and sand loam predominating in the valleys, and a gravelly clay soil, with detached stone, prevails on the hills.

West of the lake, the central portion of the summit is principally clay; the remainder, together with the soil through the valley to the Brito harbor, has much uniformity, varying but little in the proportions of clay, sand and gravel, of which it is composed.

The surface soil in the southern part of the State is generally fine, and contains enough of vegetable mould to render it capable of great production. Among the staple articles of produce that would, during the construction of the canal, be most required for consumption, may be named: corn, plantains and beans; of the

quently a mass of equal weight revolving opposite to the crank, and at the same distance from the centre, exactly balances them. Equal and opposite horizontal forces are continually developed, while the vertical action of the counterweight can produce no disturbing effect, on account of the perfect resistance of the earth, and, whatever the speed, the engine runs like a truly balanced wheel.

former and latter, two crops are annually raised, on the same ground. Numerous other edibles are produced west of the lake in less quantities, though sufficient for home consumption; among these are bananas, oranges, lemons, pine-apples and cocoa-nuts; also squashes, melons, tomatoes and other garden vegetables common in the north. Cocao is plentifully produced and considerable quantities of indigo, also rice and tobacco are now grown, and the country is capable of producing cotton, sugar-cane, and all the articles above enumerated, including the other varieties of tropical vegetables and fruits, to almost any desirable extent, and of great perfection.

Although it is to be admitted, that with such a market as would be created by the construction and subsequent use of the canal, the country would be rendered one of the most inviting to the agriculturist, and that its capabilities of production and superior advantages of market would be sufficiently attractive to ensure its early settlement, if not simultaneous with the general commencement of the work upon the canal; also, that the fine varieties and great abundance of its timber for cabinet ware, in connection with the demand produced by the canal, and the general improvement of the country, for common lumber, would be sufficient to ensure the introduction of the various kinds of machinery necessary for its manufacture; still, it is scarcely to be expected that this will be accomplished in season to produce the advantages usually available in prosecuting similar work in previously well-settled countries.

Hence the necessity of importations, at least to the extent before recited, which, together with other contingencies named, will tend very much to swell the cost of the work; their consideration, therefore, cannot, with propriety, be omitted in determining prices to be adopted in the estimate of the cost of the canal, and as they evidently tend to much embarassment and uncertainty in arriving at a fair valuation of the work, some of the prices used may be above, as it is preferred they should be, rather than below its actual cost.

In the estimate, the line is divided at the lake; that portion lying between Lake Nicaragua and the Pacific is distinguished as the western, the lake as the middle, and that between the lake and the Atlantic, the eastern division. The report of J. D. Fay, Esquire, principal assistant, containing in detail the estimated quantities, cost, &c., of the sections and works necessary in the construction of the canal, are hereto appended and marked A, and to which, for a knowledge of the prices adopted in the estimates, &c., reference may be had; it furnishes the following results:—

STATEMENT *of the distances, kind of work, and the estimated cost of constructing a Ship Canal from the Atlantic to the Pacific Oceans, in the State of Nicaragua.*

EASTERN DIVISION.

Kind of Work.	No. of Structure.	From Place to Place.		Distance in miles.	Amounts.
		From	To		
Slack-water Navigation.					
Under water excavation of Bars, &c.	....	....	....	....	792,383 80
Section work around dams	....	Fort San Carlos.	To and including Dam No. 7.	90·80	444,179 75
Locks	8	....	....	....	1,985,965 52
Dams	7	....	....	....	1,572,021 40
Inland Canal.					
Section work	4	Dam No. 7.	Artificial Harbor at foot lock 14.	27·76	4,651,970 35
Locks	6				1,471,598 89
Culverts	4				33,446 40
Section work	....	Artificial Harbor at foot lock 14.	Line of coast of Harbor.	0·52	649,543 10
Section work	....	Line of coast of Harbor.	17 feet depth of water in Harbor.	0·225	240,602 00
			Breakwaters or Jetties.	....	635,640 00
			Light House.	....	25,000 00
			Total,	119·31	$12,502,346 21

RECAPITULATION.

Slack-water navigation from Fort San Carlos to Dam No. 7	90·80	4,794,550 47
Inland Canal from Dam No. 7 to line of coast in San Juan Harbor	28·28	6,806,553 74
From line of coast of Harbor to 17 feet depth of water,	0·225	240,602 00
Breakwaters or Jetties	....	635,640 00
Light House	....	25,000 00
Total	119·31	$12,502,346 21

MIDDLE OR LAKE DIVISION.

Kind of Work.	From Place to Place. From	From Place to Place. To	Distance in miles.	Amounts.
Section work in Jetties............	Line of coast at River Lajas....	17 feet depth of water..............	0·312	393,025 00
Do. do. and Piling	Near Fort San Carlos	" " " near Boccas island	5·000	632,651 15
Lake navigation exceeding 17 feet depth of water,			51·188	
Total....................................			56·500	$1,025,676 15

WESTERN DIVISION.

Kind of work.	No. of Struct.	From Place to Place. From	From Place to Place. To	Distance in Miles.	Amounts.
Sections.......	4	....	....	....	$7,788,881 39
Locks..........	14	....	....	....	3,144,013 77
Dam	1	....	....	....	85,823 19
Water Weir.	1	Line of coast of Lake at River Lajas.....	Artificial Harbor at foot of Lock 14................	17·741	70,775 94
Culverts..	2	....	....	....	17,063 84
Bridges........	5	....	....	....	70,933 09
Receivers... ..	2	....	....	....	50,626 07
Section work.	......	Artificial Harbor at foot of Lock 14........	Line of coast of Pacific............	0·584	1,526,980 09
Section work.	.....	Line of coast of Pacific.....	To 17 feet depth of water	0·263	656,904 00
Breakwaters or Jetties....	......	....	....	....	459,601 96
Light house..	......	....	....	....	25,000 00
				Total......	$13,896,603 34

RECAPITULATION.

From line of coast of Lake to line of coast of Pacific...	18·325	12,755,097 38
" " " Pacific to 17 feet depth of water.	0·263	656,904 00
Breakwaters or Jetties..	....	459,601 96
Light House	....	25,000 00
Total......................................	18·588	$13,896,603 34

GENERAL SUMMARY.

Description.	Miles.	Total Miles.	Amounts.	Total Amounts.
INLAND CANAL.				
From line of coast of Lake at river Lajas to line of coast of Pacific	18,325		$12,755,097 38	
From Dam No. 7 to line of coast of San Juan Harbor...	28,280		6,806,553 74	
Total inland canal...............	....	46,605	....	$19,561,651 12
LAKE NAVIGATION.				
From line of coast of Lake at river Lajas to 17 feet depth of water in the lake..........	0,312		393,025 00	
From Fort San Carlos to 17 feet depth of water in lake...	5,000		632,651 15	
Lake navigation exceeding 17 feet depth of water...........	51,188			
Total lake navigation..........	....	56,500	....	1,025,676 15
SLACK-WATER NAVIGATION.				
Total slack-water navigation from Fort San Carlos to Dam No. 7.......................	90,80	90,800	4,794,550 47	4,794,550 47
From coast to coast.............	....	193,905	....	$25,381,877 74
From line of coast of Pacific to 17 feet depth of water....	0,263	....	656,904 00	
From line of coast of Atlantic to 17 feet depth of water....	0,225	....	240,602 00	
Total from coasts to 17 feet depth of water....................	....	0,488	....	897,506 00
Breakwaters or Jetties.........	....	....	1,095,241 96	
Light Houses.......................	....	....	50,000 00	1,145,241 96
				$27,424,625 70
Add for contingencies 15 p. c..	....	....	....	4,113,693 85
Tot. dist. and estimated cost..	....	194,393		$31,538,319 55

The prices adopted in the estimates* are made up with reference to the completion of the work within six years from the time of breaking grounds, and a commencement of the settlement of the country in the vicinity of the line, previous to the letting of the contracts. The cost will depend much on the early and rapid progress of the improvement of the country, and the general economy practiced in conducting the work; with success in the former, and a due observance of the latter, the fullest confidence is entertained, that the canal can be constructed for the sum above stated.

* Appendix A.

The average of the prices adopted in the estimate are believed to be 100 per cent. greater than would be the cost of similar work if located in the State of New York, and the opinion is also entertained, that contracts for the whole work may be made with competent and responsible men, at prices less than those contained in the estimates.

TABULAR STATEMENT OF DISTANCES AND FALL.

FROM PLACE TO PLACE. From	To	Distance in miles.	Distance from place to place in miles.	Total dist. from place to place in miles.	Fall from place to place in feet from Highlake	Total fall from Summit level in feet.
Summit Level.						
Head of Lock No. 1 at Castillo Rapids, or eastern termination of Summit level	Lake at San Carlos	37 151				
San Carlos	West coast of Lake at Rio Lajas	56 500				
Latter point	Head of Lock No. 1, at western termination of summit level	7 779				
Total length of summit level		103 430				
Levels east of Summit.						
Head of Lock No. 1.	Head of Lock No. 2.		0,125		8 00	8.00
Do. do. 2.	Do. do. 3.		7,303	7,428	8.00	16.00
Do. do. 3.	Do. do. 4.		3,921	11,349	8,00	24.00
Do. do. 4.	Do. do. 5.		0,162	11.511	6.50	30,50
Do. do. 5.	Do. do. 6.		20.049	31.560	8,00	38,50
Do. do. 6.	Do. do. 7.		7.538	39 098	8.00	46,50
Do. do. 7.	Do. do. 8.		8.600	47.698	8 00	54.50
Do. do. 8.	Do. do. 9.		13,231	60,929	8.00	62.50
Do. do. 9.	Do. do. 10.		5.760	66,689	8.00	70,50
Do. do. 10.	Do. do. 11.		1,740	68,429	8,00	78,50
Do. do. 11.	Do. do. 12.		7,000	75,429	8,00	86.50
Do. do. 12	Do. do. 13.		4,040	79,469	8,00	94.50
Do. do. 13.	Do. do. 14.		1,940	81,409	8,00	102,50
Do. do. 14.	17 feet depth of water in San Juan Harbor.		0,745	82,154	6,23	108,73
Levels West of Summit.						
Head of Lock No. 1, at Buen Retiro.	Head of Lock No. 2.		0.500		8.00	8.00
Do. do. 2.	Do. do. 3.		0.425	0.925	8.00	16,00
Do. do. 3.	Do. do. 4.		0.675	1.600	8.00	24.00
Do. do. 4.	Do. do. 5.		0.337	1.937	8.00	32.00
Do. do. 5.	Do. do. 6.		0 863	2.800	8.00	40.00
Do. do. 6.	Do. do. 7.		0.900	3,700	8,00	48.00
Do. do. 7.	Do. do. 8.		0.550	4,250	8.00	56.00
Do. do. 8.	Do. do. 9.		1,175	5.425	8.00	64.00
Do. do. 9.	Do. do. 10.		0.600	6,025	8.00	72.00
Do. do. 10.	Do. do. 11.		0,562	6.587	8.00	80,00
Do. do. 11.	Do. do. 12.		0,988	7.575	8.00	88,00
Do. do. 12.	Do. do. 13.		0.137	7.712	8.00	96.00
Do. do. 13.	Do. do. 14		0,250	7,962	8.00	104,00
Do. do. 14.	17 feet depth of water in Brito Harbor.		0,847	8,809	7,47	111,47

SUMMARY OF ABOVE TABLE.

Length of Summit Level	103,430 miles,
Do. Levels East of Summit	82,154 do.
Do. do. West do.	8,809 do.
Total length of canal to 17 feet water in either ocean	194,393 do.
Whole fall from Highlake to low tide in the Pacific	111 47-100 feet.
Do. do. do. do. do. Atlantic	108 73-100 do.
Total Rise and Fall	220 20-100 do.

Mechanics, Physics, and Chemistry.

SPECTROSCOPIC NOTES.

By Prof. C. A. Young, Ph.D.

(Professor of Natural Philosophy and Astronomy in Dartmouth College.)

A new Form of Spectroscope.—The instrument, a description of which follows, was designed for attachment to the equatorial of 6·4 inches aperture and 9 feet focal length, belonging to the observatory of Dartmouth College. It is specially intended for observations upon the solar spots and protuberances, and accordingly the principal object kept in view has been to combine a very high degree of power with compactness, lightness, facility of manipulation, and firmness of construction. Having the dispersive power of 13 prisms of heavy flint, each with an angle of 55°, it yet weighs less than 15 pounds, and measures over all 15 inches in length, 8 in breadth and 4½ in height. It was made by Alvan Clark & Sons.

The accompanying plate (Fig. 1), taken from a photograph, gives a correct idea of its appearance and general arrangement. The collimator and observing telescope have each an aperture of ⅞ths of an inch, and a focal length of 7 inches, which might advantageously have been increased to 12 inches were it not for the necessity of compactness.

The light from the slit after passing the collimator, is transmitted through the lower portion of a train of 6 prisms of heavy flint glass each 2¼ inches high, and having, as stated above, a refracting angle of 55°. A seventh *half-prism* follows, and to the back of this is cemented a right-angled prism by which, after two total reflections, the light is sent back through the upper part of the same train of prisms, until it reaches the observing-telescope. This is placed directly above the collimator, and firmly attached to it. Finally, a diagonal eye-piece brings the rays to the eye in a convenient position for observation.

The instrument thus has the dispersive power of 13 prisms, and even with the low magnifying power of only five on the observing-telescope, shows perfectly the lines of aqueous vapor, which make their appearance between the sodium lines when the sun is near the horizon. Of course, everything shown on the maps of Kirchhoff and Angstrom is readily seen with it, and many lines besides.

Its definition is very beautiful, and the only optical fault of the instrument seems to be a curvature of the lines, resulting from the shortness of the collimator.

After planning the instrument I learned that the same idea of sending the light twice through the prisms by a right-angled prism at the end of the train had also occurred to Mr. Lockyer and others; but I do not know that it has yet been put in practice elsewhere.

The prisms, for protection and convenience of handling, are set in frames of blackened brass. They are arranged around the circumference of a hollow cylinder of elastic gun metal, 3½ inches in diameter, with stout flanges above and below, between which they are clamped by little thumb-screws, so that they can be readily removed or transposed: it requires less than a minute to put the last prism with its reflector in place of any other of the train, thus reducing the dispersive power to any extent desired.

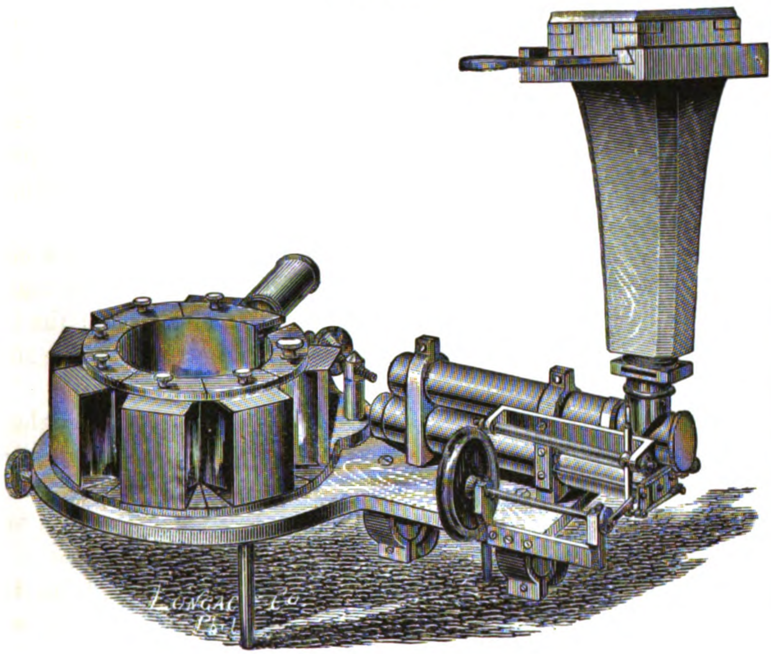
No particular care is required in placing the prisms, as a couple of narrow flanges were cast upon the cylinder near the top and bottom, and afterwards planed off to form true bearings for the backs of the prisms. They are thus always correctly set by being simply slid home before tightening the clamping screws.

The lower flange of the cylinder is attached to the base-plate by a screw directly under the middle of the front face of the first prism. Around this point as a centre the whole system of prisms is movable by means of a double threaded tangent-screw, which brings the different portions of the spectrum into the field of view.

The adjustment of the prisms to their angle of minimum deviation is effected by a method devised by Mr. George Clark, which is exceedingly simple, and, if not theoretically exact, answers every practical purpose. The flanges between which the prisms are clamped, are sawed through between the prisms, and a portion of the cylinder, flanges and all, equal to an arc of about 30°, is cut out between the first prism and the last. On closing up or spreading open this gap by means of a suitable tangent-screw, the circumference of the circle around which the prisms stand is correspondingly enlarged or diminished. Probably, when the ends of this opening are drawn very near together, or spread very far apart, the cylinder is somewhat distorted, and a corresponding mal-adjustment of the prisms results; but if so the effect is very slight.

The instrument gives a perfect view of every part of the spectrum from below A to H: above *h*, however, when all 7 prisms

FIGURE 1.



A NEW FORM OF

SPECTROSCOPE,

DESIGNED BY

Prof. C. A. YOUNG, Dartmouth College, N. H.

Longacre & Co., Engrs. & Prs. 30 & 32 S. 7th, Phila.

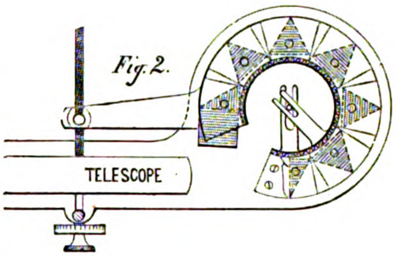
are used, there is a loss of light occasioned by a partial obstruction of the apertures of the collimator and telescope by the corner of the reflecting prism.

Were it important to secure the perfect cylindricity of the prism-frame through the whole range of adjustment it could be easily done by merely fastening at the back of each prism a radial bar acting upon a central pin as in the arrangement first devised by Mr. Rutherfurd, and since adopted by Mr. Browning, in his automatic spectroscope.

This plan of Mr. Clark's, doing away with all joints and hinges, has the great advantage of perfect firmness and solidity in every position of the instrument, an advantage hardly to be overrated in an astronomical spectroscope.

Had it occurred to me in season I might have made the instrument still simpler, firmer and perfectly automatic in its adjustment, by merely substituting for the first prism a *half prism*,* like the last of the train, to which the right-angled reflecting prism is cemented.

Placing this first *half prism* with its front face perpendicular to the line of collimation it would never need to be disturbed; the flange of the cylindrical frame which carries the prisms would be firmly fastened to the bed-plate immediately beneath it, and the pivot joint at this place with the corresponding tangent-screw would be dispensed with. The only adjustment required would be that produced by the screw which is now used to adjust for minimum deviation by opening or closing the gap of the cylinder.



Of course, this arrangement would reduce the dispersive power of the train by the amount of one prism, a loss easily made up by adding a degree or two to their refracting angles.

Fig. 2 exhibits the plan of the proposed arrangement, and requires no explanation, unless to remark that for the sake of distinctness I have represented only two of the radial bars which may be used to render the adjustment accurate.

* On returning from the Eclipse Expedition my instrument will be made automatic in accordance with this plan.

It might be better to place the face of the first prism not exactly normal to the line of collimation, in order to avoid repeated reflections between it and the object-glass of the collimator, which would be likely to produce a troublesome ghost, or the same thing might be accomplished by simply cementing the object-glasses of both collimator and observing-telescope, directly upon the front of the prism; this would make the instrument still more solid and compact.

The eye-piece of the instrument has an apparatus attached, which, however, thanks to the high dispersive power, I find unnecessary.

It was early proposed by Janssen to use a vibrating or rotating slit in order to make visible the form of a solar prominence, but as Zöllner has shown, the mere opening of the slit answers just as well, the light of the protuberance being diluted to precisely the same extent in either case.

It occurred to me in connection with a suggestion of Professor Morton, that by interposing at the focus of the eye-piece a diaphragm which should move with the vibrating slit, the light of the neighboring portions of the spectrum might be cut off and this dilution avoided. Mr. Clark has devised and constructed a very beautiful mechanical arrangement by which this simultaneous and accordant motion of slit and diaphragm is effected by the rotation of the small fly-wheel shown in Fig. 1, (Pl.)

But I find, that although seen in this way, the prominences appear very bright; yet the working of the apparatus always causes a slight oscillation of the equatorial, which interferes with the definition of details, and I prefer to work with the slit simply opened. When the air is free from haze, the whole extent of a prominence 30,000 miles in height is readily examined through the C or F line, and the most delicate details reveal themselves, with a beauty and clearness of definition which even yet always surprises me, and speaks most emphatically for the exquisite workmanship of the 43 different surfaces by which the light is either refracted or reflected on its way from the slit of the collimator to the eye.

But, although I do not use the vibration of the slit and diaphragm, I find the mobility of the slit so convenient as to be practically indispensable. In examining the spectrum of a group of sun spots, for instance, it is very much easier to move the slit to the particular point we wish to observe than to move the solar image by the tangent screws of the equatorial.

Photographs of the Solar Protuberances.—The protuberances are so well seen through the F and 2796 (*near* G) lines, that it is even possible to photograph them, though, perhaps not satisfactorily with so small a telescope as the one at my command. Some experiments I have recently made show that the time of exposure, with ordinary portrait collodion, must be nearly 4 minutes, in order to produce images of a size which would correspond to a picture of the solar disk about 2 inches in diameter. This length of exposure demands a more perfect clockwork than my instrument possesses, and a more accurate adjustment of the polar axis than it had during the experiments, as well as a steadier condition of the atmosphere.

Thus far, therefore, I have not been able to produce anything which could properly be called a good picture. Negatives have been made which show clearly the presence and general form of protuberances, but the definition of details is unsatisfactory. This amount of success was reached upon September 28, when impressions were obtained of two protuberances on the S. E. limb of the sun, and, slight as this success was in itself, I consider it of importance in showing the perfect feasibility of going much further with more sensitive chemicals, more delicate adjustments, and greater telescopic power. I was aided in the experiments by Mr. H. O. Bly, our local photographer, to whom are due my warmest acknowledgments for the interest, patience, ingenuity and skill, with which he assisted me.

We worked through the Hydrogen γ line (2796 of Kirchhoff's scale) which, though very faint to the eye, was found to be decidedly superior to F in actinic power. The photographic apparatus employed consisted merely of a wooden tube, about 6 inches long, attached at one end to the eye-piece of the spectroscope, and at the other carrying a light frame. In this frame was placed a small plate-holder, containing for a sensitive-plate an ordinary microscope slide, 3 inches by 1. The image of the prominence, seen through the open slit, is magnified and thrown upon this plate by the eyepiece. Fig. 1 (Pl.) shows the instrument with this apparatus attached.

It would be easy to improve this arrangement in many respects, and whenever I resume the subject, I propose to do so.

As the equatorial, however, has been dismounted, to be put in order for the observation of the December eclipse, further attempts in this direction must be postponed until next spring.

Observations of the Solar Protuberances.—Without prolonging this article with the detail of observations, I add a few of the results which have been obtained since Sept. 10th.

About 40 different prominences have been more or less carefully observed: 16 have been sketched. Most of them fall, naturally enough, into the categories established by Zöllner and Lockyer, and are fairly represented by figures already published in this *Journal.*

A few deserve especial mention, however. Fig. 3 represents a small one which was observed upon the E. limb of the sun, on September 14th, about 4·30 P. M. From the point marked A, which was very brilliant, a small fragment detached itself and rose towards A′, enlarging in size and growing fainter as it rose. It disappeared (from faintness) in about 12½ minutes, at a distance of 2′ 30″ above the limb of the sun, as determined by the time, 8ˢ·5, which was occupied by the intervening space in passing over the slit of the spectroscope. Allowing for the obliquity of the motion to the parallel of declination, the length of path passed over by this cloud was more than 90,000 miles, and the velocity above 120 miles per second.

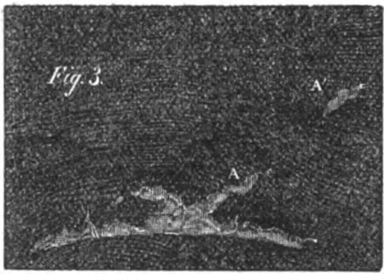
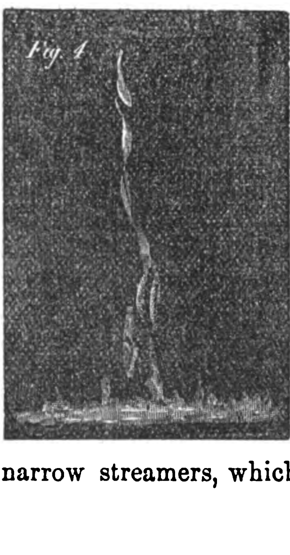


Fig. 4 represents a prominence observed September 20th, at 4 P. M., on the S. E. limb. (Pos. S., 60° E.) It was a nearly vertical stream, made up of spindle-formed filaments, and had attained the enormous height of 3′ 20″ or 90,000 miles (determined, as in the case above mentioned, by a time-observation, corrected for inclination). It was very brilliant near the base, and at two or three other points along its length. At 4·30 it was nearly gone, only a few faint wisps of cloud remaining.



Another, observed on September 27, at 4·10 P. M., and situated on the W. limb of the sun, is represented in Fig. 5. It was formed of separate, well-defined narrow streamers, which appeared to consist of matter, first vio-

lently ejected, and then as violently deflected, by some force acting nearly at right angles. The altitude of the highest point was 1′ 25″, the length of the whole about 3′ 30″. I am unable to see how any mere projection from the sun could have produced such a form, and cannot help feeling that it indicates a *something* in which powerful currents may exist, even at such great elevations above the solar surface; in short, an atmosphere extending far beyond the limits which calculation would seem to assign as possible. Is it wholly unlikely that at such an enormous temperature the law of Mariotte may fail so completely as to destroy the reliability of any computation that assumes it as one of the data?

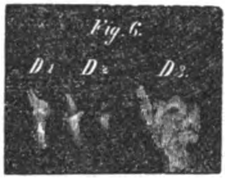
Upon the next day the prominence still persisted, but its type was wholly changed: it was replaced by one of the mushroom-formed masses which are so common.

Bright Lines.—In the spectra of different protuberances, the following bright lines have been observed, the numbers referring to Kirchhoff's scale: C; D_1; D_2; D_3; 1474; 1515; b_1; b_2; b_3; b_4; 1990; 2001; 2031; F; 2581·5; 2796; h—17 in all. On one occasion, September 27, the base of a prominence on the N. W. limb, close to a spot just leaving the limb, exhibited as many as 12 or 15 short bright lines between E and F, which are not included in the above enumeration, as I had not time to identify them. It is the only instance in which I have seen this phenomenon, more than once described by Mr. Lockyer.

I desire to call special attention to 2581·5, the only one of my list, by the way, which is not given on Mr. Lockyer's. This line, which was conspicuous at the eclipse of 1869, seems to be *always present* in the spectrum of the chromosphere, and shows the form of its upper surface or of a protuberance nearly as well, though of course not so brightly, as the 2796 line. It has no corresponding dark line in the ordinary solar spectrum, and not improbably may be due to the same substance that produces D_3.

The reversal of the sodium and magnesium lines is not at all uncommon. In some instances these lines were so bright, that on

opening the slit, the form of the prominence could be made out through them. This was the case with a small hand-shaped prominence observed on September 27th. Comparing the form thus seen through D^1 and D_2 with that given by D_3, it appeared that the sodium line was sufficiently developed for observation only along the edge and at one or two bright points in the prominence, most brilliantly neither at its summit nor its base. Fig. 6 represents the appearance; (the slit was perpendicular to the sun's limb.) The case was similar with the magnesium lines.



Spectrum of Solar Spots.—Several spots have been carefully examined at different times, most of them, in their spectra, gave evidence of unusual disturbances; but by far the most interesting phenomena were exhibited by a large group which was first observed near the E. limb on September 19th. Changes of wave-length were frequent in its neighborhood.

Figs. 7 and 8 represent the appearances assumed by the F and C lines respectively, at the times indicated below each figure, during an observation on the afternoon of September 22d. The point

Fig. 7. F.

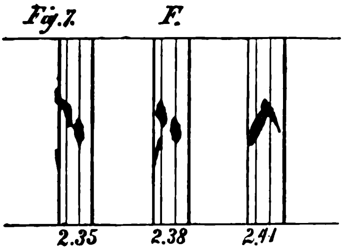
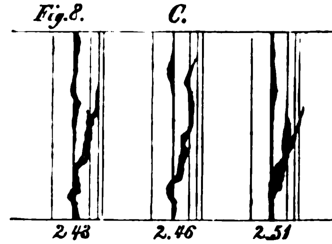


Fig. 8. C.



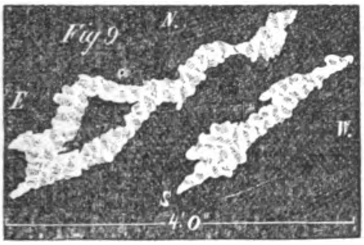
where these changes of wave-length occurred was at the western edge of the penumbra. At other times similar changes were observed, but not so great or rapidly varying.

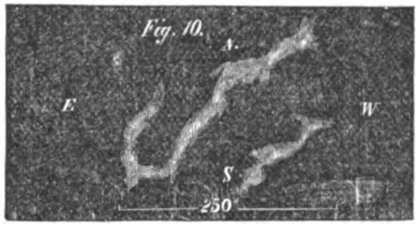
The calcium and titanium lines referred to in my note, published in the July number of this *Journal*, were always conspicuously thickened in the nucleus spectrum.

The C and F lines were reversed in some portion or other of the group nearly every time I observed it. On September 22d, the *sodium* lines were both reversed for several hours, while D_3 appeared as a dark shade. On September 28th, again, at 4 P. M., the south-

ern nucleus of the group (which at this time contained 4 large umbræ, besides many small ones,) reversed all of the following lines, viz.: C; D_1; D_2; D_3; 1474; b^1; b_2; b_3; b_4; F; 2796, and h. All of these were *conspicuous*, except 1474; D_3 and b_3 especially so, and the latter (a nickel line) showed considerable changes of wave-length, alternate increase and diminution, which were not shared by its magnesian neighbors, b^1, b_2 and b_4.

At 4·05 P. M. the brilliance of the F line increased so greatly that it occurred to me to widen the slit, and to my great delight I saw upon the disk of the sun itself a brilliant cloud in all its structure and detail identical with the protuberances around the limb. Indeed, there were *two* of them, and there was no difficulty in tracing out and delineating their form. Fig. 9 represents them as they were from 4·05 to 4·10; Fig. 10 gives the form at 4·15–20. They





were then considerably fainter than at first. During the intervening 10 minutes I examined the other lines of the spectrum, and found that the form could be distinctly made out in all the *hydrogen* lines even in h; but that the reversal of the other lines, including D_3, was confined to the region immediately over the spot-nucleus, where the smaller but brighter cloud terminated abruptly; or, I might better say, *originated.* The larger one faded out at both ends. When the clock-work of the equatorial was stopped, the luminous cloud took 16·7 seconds of time to traverse the slit which was placed parallel to the hour-circle. This indicates a length of at least 130,000 miles without allowing anything for the foreshortening resulting from the nearness of the sun's limb.

By 5 o'clock the clouds had nearly disappeared; a little rack alone remained.

At 4·20 I examined the spot with the equatorial, using the ordinary solar eye-piece. Nothing remarkable was to be seen—not the merest trace of the enormous masses of incandescent gas. It will

be interesting to learn whether the earth responded to this magnificent eruption on the sun by any magnetic storm.

I may add that in the telescope this group of spots, from their first appearance, exhibited a strong yellowish tinge, which appeared to overlie all the central portion of the cluster. So conspicuous was it that several persons, unaccustomed to astronomical observation, noticed it at once before I called their attention to it. The penumbra of the group was unusually faint.

Hanover, N. H., October 3d, 1870.

THE SUN.

(A course of five lectures before the Peabody Institute of Baltimore, January, 1870.)

By B. A. Gould.

(Continued from page 262.)

The invention of the spectroscope, and the discoveries to which it has led within the last few years, have permitted an analysis of the sun and other stars, and thus many of their chemical constituents have been revealed to us. Much is yet unexplained, and much remains to be discovered, yet it appears well established that in the solar atmosphere, the vapors of at least 16 metals known to us may be recognized, of which those giving the most conspicuous tokens, are iron, sodium, calcium, magnesium and hydrogen. The light of every star seems to exhibit individual peculiarities, so that the star might be recognized by a drawing of the lines in its spectrum. In the light of Aldebaran, indications of 9 metals have been found, 4 of which, viz., bismuth, tellurium, antimony and mercury are not recognizable in the sun's light. Of all the stars there are but two in which hydrogen may not be detected.

I have endeavored to exhibit as concisely as the case would admit, a general idea of this magnificent luminary in its relations to the rest of the material universe. Of its enormous effluence of light, heat and other energies, less than the two-billionth part is received by our own planet, and less than two hundred millionth part by all the planets of our system taken together. What mighty work in the vast economy of the universe is accomplished by the countless floods of almost immeasurable force thus radiated into space by the myriad of stars with which science is acquainted, the

science of to-day is unable even to surmise. But this we do know, that light and heat are power, and that even the relatively insignificant portion of all this emanation which is intercepted by our earth suffices to yield us all terrestrial energy.

Upon the vivifying beams of light, heat and chemic force which we receive from our own resplendent luminary, all terrestrial power seems to depend. The sunbeams of remote geological ages stored up in beds of coal and subterranean lakes of oil, provide us to-day with the force which propels the locomotive and the steamship, and effect the transformations of matter which the arts demand,—and they afford us light and heat, while the fountain of their radiance is illuminating the other hemisphere. The summer's rays are stored up for winter's use in the animal and plant; they furnish us the very texture of our material frames and all our muscular and vital powers; and in the fulfilment of the magnificent scheme, even those rays which fall on the most trackless wastes or unknown seas, are lifting the vapors to descend in diffusive rains,—watering the earth and yielding their power to the service of man in mountain torrents or stately rivers,—and are evoking the winds which sweep the earth, purifying the atmosphere, and wafting the sails of commerce through every zone. The benignant influence of his rays, direct or indirect, seems a necessary condition for vital action, whether vegetable or animal; and there is the strongest reason to believe that essentially all the physical forces now in action upon our globe, the electricity which awes us in the thunderbolt, and flashes our errands from the eastern to the western shores of the Pacific, across both continents and the dividing ocean,—magnetism, which points the unerring needle to its pole, while it performs some mysterious but important part in maintaining the balance of material power for our planet; every mechanical action by which gravitation is called into play; all chemic force, in whatever form it may manifest itself, are due to these same quickening beams. If there be an exception, it must be sought in forces from below the crust of our earth, such as the volcano and the earthquake, and even here there is much room for doubt whether these, too, are not varied manifestations of solar energy.

Our next inquiries must be into the information which the telescope reveals to us concerning this wondrous luminary.

I have spoken of the intense light and heat which stream in profuse radiance from the sun. The human eye shrinks, blinded from

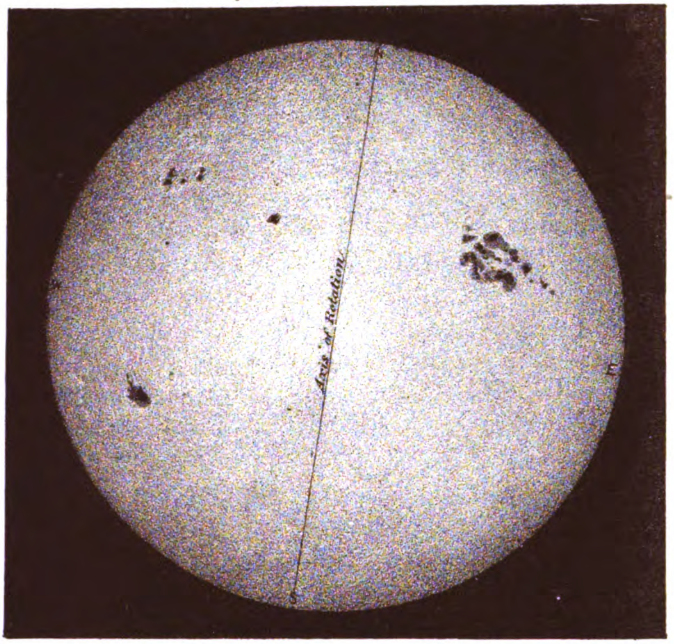
these dazzling beams, for no man can fix his unprotected gaze with impunity upon the unclouded orb. Yet it is upon observation alone that we must depend for the foundation of our knowledge as to his nature. Screening our eyes from his excessive light by some very imperfectly transparent material, or regarding it through a thick fog or haze, we discern merely a bright disk. Gallileo was wont to scrutinize the sun near the times of its rising or setting, when the vapor or murkiness of the horizon greatly obscured its brilliancy; yet to these observations that inflammation of the eyes was attributed, which deprived him of the priceless opportunities of continuing his astronomical researches, and finally resulted in his total blindness.

Keppler predicted a transit of Mercury for the 29th November, 1606, and, in his endeavors to observe it, availed himself of a method which had been previously employed for the observation of eclipses, viz., the camera obscura; for the method of obtaining images of objects by causing the light from them to pass through a small aperture into a dark room, and there to be received upon a screen, was well known. The telescope was not invented until two years later than this, nor was its use general, for three or four years later yet. At the time, Keppler supposed that he actually did see Mercury upon the solar disk, and published a work* to announce this; but what he saw must, as he himself subsequently became convinced, have been a solar spot, for Mercury is not large enough to be visible under the circumstances without a telescope. Not long afterward, Capelli, one of Kepler's pupils, substituted a telescope for the small aperture of the camera obscura, and thus introduced the method which is very generally employed to-day for the observation of solar spots and eclipses. The image formed by the telescope is received not upon the eye, but upon a sheet of white paper or card-board, and when the distance is properly adjusted, an exquisitely well-defined and enlarged representation of the sun is formed upon the paper. This is, in many respects, the most convenient mode of examining the sun. But when the delicate details of the surface are to be examined, this method is inadequate, and direct vision must be employed. For this purpose colored glasses are interposed to protect the eye, and when a neutral tint can be obtained, the structure of the solar surface can thus be studied with great advantage. But sometimes the intense heat thus

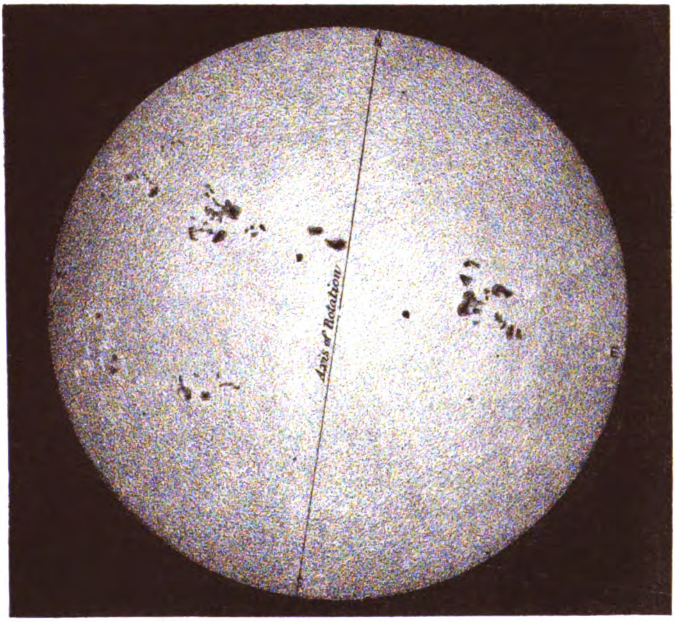
* *Mercurius in Sole, etc.*, 1609.

The Sun

(From Photograph made by L.M. Rutherfurd)



1870. March 16th 2h. 44m. 56s. Siderial time



1870, Aug. 27th 6h. 45 m. 40 s. Siderial time

concentrated upon the shade-glass is more than it can bear, and it breaks, under the trial, to the great danger of the astronomer's eye; and more than one serious accident of the sort has occurred.

The discoverer of the telescope himself is said to have died of an inflammation of the eyes, brought on by examining the sun with his new implement of research; and, in 1643, the professor of astronomy at Oxford injured his vision so much by measurements of the sun's diameter, that for a long period afterward he could scarcely see anything but what appeared "like flocks of crows in the air."

To guard the observer's eye, and to avoid the false tints almost invariably imparted to the image by colored shade-glasses, it is now usual to receive this telescopic image upon inclined plates of white glass, which transmit the greater part of the light and heat, and to view the reflected image only, which the eye can receive without inconvenience. This process was first suggested by Sir William Herschel, but has been improved since his day, by his son, by Porro, Dawes, Tolles and others, until scarcely anything is left to be desired in this respect.*

But of late years photography has furnished another and a most effective mode of studying the sun, although it is one in which great caution is requisite in distinguishing between what is really the representation of solar phenomena and what is merely due to the character of the chemical agents and processes employed. The devices and experiments of Mr. Rutherfurd, of New York, and Mr. De la Rue, of London, have given a great impulse to all celestial photography, and have led to a series of practical advances, which, so far as solar photography is concerned, seem to have reached their highest excellence in the wonderfully beautiful impressions taken by the photographic parties of the government expedition under Prof. Coffin, for observation of the total eclipse of August last. These parties, organized and directed by Prof. Henry Morton, of Philadelphia, obtained a series of photographic views of the sun, both uneclipsed and in every stage of its observation, which far surpass all previous results of the sort.

As early as 1854, photographic impressions of the annular eclipse of that year were obtained at several places in the United States, and a series of 19 photographic views of the various stages of this eclipse taken under the direction of Prof. Bartlett, of West Point,

* For a description of Dawes' eye-piece, see *Mem. R. Astr. Soc.*, XXXI., 161.

was appended to his description of this eclipse in the *Astronomical Journal.**

In the year 1858, a system of daily photographs of the sun was instituted at the Physical Observatory of Kew, near London. This has been regularly prosecuted since that time, to the great benefit of science, and valuable inferences have been already deduced from the results, by three gentlemen in charge of this observatory.

Thus equipped with the solar eye-piece and the photographic apparatus, astronomers have assailed, with redoubled energy, the troublous problem which the sun's aspect offers to the observer, and each successive month now seems to bring us new knowledge in this regard, while the added scrutiny which the spectroscope permits, furnishes a new and most powerful ally for the exploration.

(To be continued.)

ABSOLUTE SYSTEM OF ELECTRICAL MEASUREMENTS.

By Josiah P. Cooke, Jr.

(Continued from page 272.)

17. *Resistance.*—Even when the electro-motive force between two points is constant, so that the total work done by the transfer of a given quantity of electricity remains unchanged, it is found by experiment that nevertheless, by modifying the material and size of the conductor, this transfer may be made to take place in very different times; or, in other words, currents of very different magnitudes are produced, and in the unit of time very different amounts of work are performed. The quality of a conductor, in virtue of which it prevents the performance of more than a certain amount of work in a given time, by a given electro-motive force, is called its electrical resistance. The resistance of a conductor is therefore inversely proportional to the amount of work done, or when a fixed electro-motive force is maintained between its two ends, to the amount of electricity passed through it in a given time. It is therefore inversely proportional to the current, which will be produced under these conditions. But since, as we have seen, the strength of current in any conductor is directly proportional to the electro-

* *Astron. Journal*, IV., No. 77.

motive force between its two ends, both relations are most simply expressed by the formula—

$$c = \frac{e}{r},$$

which is the well known equation expressing Ohm's law. Putting this in the form $r = \frac{e}{c}$, and substituting for e and c their equivalents in electro-magnetic measure, we have—

$$r = \frac{1}{v^2}\,\frac{\mathrm{E}}{\mathrm{C}},\ \text{but since}\ \frac{\mathrm{E}}{\mathrm{C}} = \mathrm{R},$$

$$r = \frac{1}{v^2}\,\mathrm{R}, \qquad . \quad . \quad . \quad . \quad . \quad . \qquad [20.]$$

Hence to reduce resistance measured in electro-magnetic units to the electro-static equivalent, we must divide by v^2.

The dimensions of r are—

$$\frac{\mathrm{T}}{\mathrm{L}} = \frac{1}{\mathrm{V}}.$$

Thus the measure of resistance on the electro-static system is the reciprocal of a velocity.

Table of Dimensions.

Quantity $\quad q = \dfrac{\mathrm{L}^{\frac{3}{2}}\,\mathrm{M}^{\frac{1}{2}}}{\mathrm{T}} = v\,\mathrm{Q}.$

Current $\quad c = \dfrac{\mathrm{L}^{\frac{3}{2}}\,\mathrm{M}^{\frac{1}{2}}}{\mathrm{T}^2} = v\,\mathrm{C}.$

Electro-motive force $\quad e = \dfrac{\mathrm{L}^{\frac{1}{2}}\,\mathrm{M}^{\frac{1}{2}}}{\mathrm{T}} = \dfrac{\mathrm{E}}{v}.$

Resistance $\quad r = \dfrac{\mathrm{T}}{\mathrm{L}} = \dfrac{\mathrm{R}}{v^2}.$

$v = 310{,}740{,}000$ metres a second.

18. *Electro-static Capacity.*—The electro-static capacity of a conductor is equal to the quantity of electricity, with which it can be charged by the unit of electro-motive force. Let s be the capacity, q the quantity of electricity in it, e the electro-motive force, then—

$$q = s\,e, \qquad . \quad . \quad . \quad . \quad . \quad . \qquad [21.]$$

Hence the dimensions of s are—

$$s = \frac{q}{e} = \frac{\mathrm{L}^{\frac{3}{2}}\,\mathrm{M}^{\frac{1}{2}}}{\mathrm{T}} \div \frac{\mathrm{L}^{\frac{1}{2}}\,\mathrm{M}^{\frac{1}{2}}}{\mathrm{T}} = \mathrm{L},$$

or the electro-static capacity is represented in this system by a length only. The capacity of a condenser depends, as we have seen, on a great variety of conditions, but calculation shows that the capacity of a spherical conductor in open space is equal to the radius of the sphere.

The relation of the electro-static to the electro-magnetic unit of capacity is expressed by the equation—

$$s = v^2 \, S, \qquad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad [22.]$$

19. *Specific Resistance.*—On account of the difficulty of measuring with accuracy the diameters of wires it is more convenient to refer the resistance to the mass or weight in a given length than to the section. The specific resistance of a material is the resistance of the unit weight made into a conductor of the unit length. Thus the specific resistance of copper is the resistance of a wire of that metal weighing one gramme and one meter long. If the same weight of metal be drawn out into a wire of twice the length it is obvious that the section of the wire will be diminished in the same proportion. Hence the resistance will be doubled on account of the increased length, and doubled again on account of the diminished section. So in any case *the resistance of the same weight of metal varies as the square of the length of the conductor, which it forms.* Assuming now the weight to be constant, it is evident (since the section of the same length of wire must be proportional to its weight) that *the resistance of a given length of conductor is directly proportional to its weight.* Thus we deduce for the value of the resistance of any conductor in terms of its weight and length the expression—

$$R = \frac{(\text{Sp. R.}) \times l^2}{w}, \qquad . \quad . \quad . \quad . \quad . \qquad [23.]$$

The specific resistance of pure copper at 60° C. is 0·1523 Ohm, but it changes very rapidly with the temperature.

20. *Specific Inductive Capacity.*—Faraday discovered that the capacity of a conductor does not depend solely upon its dimensions or on its relations to other conductors, but is greatly influenced by the nature of the insulator or dielectric, separating it from them. The name inductive-capacity is given to that quality of an insulator, in virtue of which it affects the capacity of the conductor it surrounds, and this quality is measured by reference to air, which is assumed to possess the unit inductive capacity. The specific inductive capacity is therefore equal to the quotient of the capacity of any con-

ductor insulated by that material, divided by the capacity of the same conductor, in the same position separated from surrounding bodies by air alone.

Calculation of Derived Currents.

21. *Shunts.*—When an electrical current branches into two or more streams, it is said to be shunted, and any conductor which diverts a portion of the current from the main circuit is called a *shunt*, contracted from shun it.* The several subordinate streams thus formed are called *derived currents*, and it becomes of great importance in telegraphy to be able to calculate the quantity of electricity flowing in each. Moreover, several of the most valuable methods of electrical measurement are applications of the theory on which these calculations are based.

Since the several derived circuits, into which the main stream divides, may branch off at the same or at different points, and may either return on the same conductor or may flow to the earth ("make earth") through separate channels; moreover, since the original electro-motive power may be reinforced at any point, it is obvious that cases of great complexity may arise under the general theory. All such problems, however, may be solved by the application of two simple principles, the definite statement of which we owe to Kirchhoff.

22. *Kirchhoff's Laws.*—The following propositions are deductions from the general theory of electrical currents, and have been proved both mathematically and experimentally.

1. *The sum of the currents which approach any point is always equal to those which recede from it.*

Or if we distinguish the first by a plus, and the second by a negative sign we may say more generally;

The sum of all the currents which meet at a point is equal to zero.

2. *On any continuous line of conductors, the sum of the products of the resistances of the several parts by the strength of the current in each part, is equal to the sum of the electro-motive forces included in the same closed circuit.*

This last proposition holds true of every circuit which may be traced in any system of conductors and batteries, however complicated the maze; only currents flowing in opposite directions with reference to the given circuit, must be distinguished by opposite signs. Moreover, the sum is equal to zero when there is no electro-motive force on the line of conductors under consideration.

* A galvanometer, for example, is said to be shunted when only a portion of the current to be measured passes through it, the rest flowing through a wire (*the shunt*), which connects the two binding cups of the instrument.

(To be continued.)

CHEMICAL TABLES ACCORDING TO THE THEORIES OF MODERN CHEMISTRY.

By Prof. Leeds.

(Continued from page 277.)

Table V.—*Continued.*

Molecule.	Sp. Gr.	Molecular Symbol.	Molecular Weight.	Logarithm.	Ar. Co.
Didymium	....	D	95·84	1·98155	8·01845
Didymic Oxide........	....	D O	111·84	2·04860	7·95140
Erbium................	....	E	112·6	2·05154	7·94846
Ferrum (Iron)........	7—8·14	Fe	56·	1·74819	8·25181
		Fe_2	112·	2·04922	7·95078
		Fe_3	168·	2·22531	7·77469
		Fe_4	224·	2·35025	7·64975
Ferric Chloride.......		$Fe_2\ Cl_6$	324·	2·51055	7·48945
Oxide...........	5 224	$Fe_2\ O_3$	160·	2·20412	7·79588
Disulphide....	4 65—5·1	$Fe\ S_2$	120·	2·07918	7·92082
Ferrous Chloride.....	2·528	$Fe\ Cl_2$	137·	2·10380	7·89620
Oxide.........	....	Fe O	72·	1·85733	8·14267
Sulphide.....	....	Fe S	88·	1·94448	8·05552
Ferrous-Ferric Oxide	5·4				
Fluorine................	....	F_2	38·	1·57978	8·42022
		F_3	57·	1·75587	8·24413
		F_4	76·	1·88081	9·11919
Glucinum	2 1 A.	G	9·29	0·96802	9·03198
	....	G_2	18·58	1·26905	9·73095
Glucinic Oxide........	....	G O	25·29	1·40295	8 59704
Hydrogen	0·0693	H_2	2·	0·30103	9·69897
		H_3	3·	0·47712	9 52288
		H_4	4·	0·60206	9·39794
		H_5	5·	0·69897	9·30103
		H_6	6·	0·77815	9·22185
		H_7	7·	0·04510	9·95490
		H_8	8·	0·90309	9·09691
		H_9	9·	0·95424	9·04576
		H_{10}	10·	1·00000	9·00000
		H_{11}	11·	1·04139	8·95861
		H_{12}	12·	1·07918	8·92082
Hydrobromic Acid...	2·71	H Br	80 97	1·90832	8·09168
Hydrochloric "	1 27	H Cl	36·5	1·56229	8·43770
Hydrocyanic "	0·947	H C N	27·	1·43136	8·56864
Hydrofluoric "	....	H F	20·	1·30103	8·69897
Hydriodic "	4·443	H I	128·	2·10721	7·89279
Hydrosulphuric "	1·191	$H_2\ S$	34·	1·53148	8·46852
Indium	7·421 at 16° ·8	In	75·63	1·87869	8·12131
		In_2	151·26	2·17971	7·82029
Indic Sulphide.........		In S	107·63	2·13193	7·96807
Iodine....................	*3·716 A.	I_2	254·	2·40483	7·59517
	4·95	I_3	381·	2·58092	7·41908
		I_4	508·	2·70586	7·29414

* Vapor.

TABLE V—*Continued.*

MOLECULE.	Sp. Gr.	Molecular Symbol.	Molecular Weight.	Logarithm.	Ar. Co.
Iodine..................		I_5	635·	2·80277	7·19723
		I_6	762.	2·88195	7·11805
Iridium.....................	21·8	Ir	197·13	2·29476	7·70524
Iron (see Ferrum)....					
Lanthanum	....	Ln	92·8	1·96755	8·03245
Lanthanic Oxide......	....	Ln O	108·8	2·03663	7·96337
Lead (see Plumbum..					
Lithium..................	0 5936 A.	L_2	14·	1·14613	8·85387
Lithium Chloride.....	1·998	L Cl	42·5	1·62839	8·37161
Oxide	....	L_2 O	30·	1·47712	8·52288
Magnesium..............	1·75	Mg	24·6	1·39094	8 60906
		Mg_2	49·2	1·69197	8·30803
		Mg_3	73·8	1 86806	8·13194
		Mg_4	98·4	1·99300	8·00700
Magnesic Chloride...	....	$Mg\ Cl_2$	95·6	1·98046	8·01954
Carbonate	2·99	$Mg\ O_3\ C$	84·6	1·92737	8·07263
Hydrate...	....	$Mg\ O_2\ H_2$	58 6	1·76790	8·23210
Oxide......	3·2	Mg O	40·6	1·60853	8·39147
Pyrophos.	....	$Mg_2\ O_6\ P_2$	207·2	2·31639	7·68361
Sulphate..	2·6	$Mg\ O_4\ S$	120 6	2·08135	7·91865
Sul. Cryst.	....	$Mg\ O_4\ S + 7H_2\ O$	246·6	2·39199	7·60801
Ammonic-mag. Phos	....	$NH_{42}\ Mg_2O_8P_2 + 12H_2O$	471·2	2·67321	7·32679
Manganese	8.013	Mn	54·96	1·74005	8·25995
		Mn_2	109·92	2·04108	7·95892
		Mn_3	164·88	2·21717	7·78283
		Mn_4	219·84	2·34211	7·65789
Manganous Chloride.		$Mn\ Cl_2$	125·96	3·10023	7·89977
Pyroph.		$Mn_2\ O_6\ P_2$	267·92	2·42800	7·57200
Oxide		Mn O	70·96	1·85101	8·14899
Sulphate	3·1	$Mn\ O_4\ S$	150·96	2·17886	7·82114
Manganic Oxide	4 9	$Mn\ O_2$	86·96	1 93932	8·06068
Manganous-man. Ox.	4·722 A. *5·976 A.	$Mn_3\ O_4$	228 88	2 35963	7·64037
Mercury (Hydrarg.).	13·596	Hg	200·2	2·30146	7·69854
		Hg_2	400·4	2·60249	7·39751
Mercurous Chloride..	*8·35 A. 6 99	$Hg_2\ Cl_2$	471·4	2·67339	7·32661
Iodide	7·75	$Hg_2\ I_2$	654·4	2 81584	7·18416
Nitrate....	....	$Hg_2\ O_2\ (NO_2)_2 + 2H_2\ O$	570·4	2·75618	7·24382
Oxide......	8·95	$Hg_2\ O$	416·4	2·61951	7·38049
Sulphate.	....	$Hg_2\ O_4\ S$	496·4	2·69583	7·30417
Sulphide.	....	$Hg_2\ S$	432·4	2·63589	7·36411
Mercuric Chloride....	*9·80 A. 5·42	$Hg\ Cl_2$	271·2	2·43329	7·56671
Iodide.......	*15·6 A. 6·257	$Hg\ I_2$	454·2	2·65725	7·34275
Nitrate......	....	$Hg\ O_2\ (NO_2)_2 + 2H_2\ O$	370·2	2·56844	7·43156
Oxide........	11·29	Hg O	216·2	2·33486	7·66514
Sulphate.. .	....	$Hg\ O_4\ S$	296·2	2·47159	7·52841
Sulphide....	*5·5 A. 8·124 A.	Hg S	232 2	2·56586	7·63414
Molybdenum...........	8 64	Mo	96·	1·98227	8·01773
		Mo_2	192·	2·28330	7·71670
Molybic Anhydride..	3·46	$Mo\ O_3$	144·	2·15836	7·84164

*Vapor.

TABLE V—*Continued.*

MOLECULE.	Sp Gr.	Molecular Symbol.	Molecular Weight.	Logarithm.	Ar. Co.
Molybic Sulphide.....	4·69	$Mo\ S_2$	160·	2·20412	7·79588
Nickel (Niccolum)...	8·9	Ni	59·02	1·77100	8·22900
		Ni_2	108·04	2·03358	7·96642
		Ni_3	177·06	2·24812	7·75188
		Ni_4	236·08	2·37306	7·62694
Niccolous Chloride...	2·56	$Ni\ Cl_2 + 9H_2O$	292·02	2·46541	7·53459
Oxide......	6·66	$Ni\ O$	75·02	1·87518	8·12482
Sulphate...	....	$Ni_2\ H_2\ O_5\ S + 6H_2\ O$	281·02	2·44874	7·55126
Nitrogen...............	0·9714	N_2	28·	2·44716	8·55284
Nitrogen		N_3	42·	1·62325	8·37675
		N_4	56·	1·74819	8·25181
		N_5	70·	1·84510	8·15490
Nitrous Acid	....	$H\ O_2\ N$	47·	1·67210	8·32790
Anhydride...	....	$N_2\ O_3$	76·	1·88081	8·11919
Nitric Acid............	1·552 at 20°	$H\ O_3\ N$	63·	1·79934	8·20066
Anhydride....	....	$N_2\ O_5$	108·	2·03342	7·96658
Oxide..........	1·0388 A.	$N\ O$	30·	1·47712	8·52288
Peroxide......	1·720 A.	$N\ O_2$	46·	1·66276	8·33724
Osmium	21·4	Os	198·8	2·29842	7·70158
		Os_2	397·6	2·59945	7·40055
		Os_3	596·4	2·77554	7·22446
		Os_4	795·2	2·90048	7·09952
Potassic-osmic Chlor.	....	$Os\ Cl_4 \cdot 2K\ Cl$	490·06	2·69025	7·30975
Oxalic Anhydride....	....	$C_2\ O_3$	72·	1·85733	8·14267
Acid............	....	$H_2\ O_4\ C_2 \cdot 2H_2\ O$	126·	2·10037	7·89963
Oxygen	1·1056	O_2	32·	1·50515	8·49485
		O_3	48·	1·68124	8·31876
		O_4	64·	1·80618	8·19382
		O_5	80·	1·90309	8·09691
		O_6	96·	1·98227	8·01773
		O_7	112·	2·04922	7·95078
		O_8	128·	2·10721	7·89279
		O_9	144·	2·15836	7·84164
		O_{10}	160·	2·20412	7·79588
		O_{11}	176·	2·24551	7·75449
		O_{12}	192·	2·28330	7·71670
Palladium..............	11 — 12	Pd	106·56	2·02760	7·97240
		Pd_2	213·12	2·32863	7·67138
Palladious Nitrate...	....	$Pd\ O_2\ (N\ O_2)_2$	230·56	2·36278	7·63722
Sulphate..	....	$Pd\ O_4\ S + 2H_2\ O$	238·56	2·37760	7·62240
Phosphorus...........	2·089	P_4	124·	2·09342	7·90658
	*4·420 A.	P_2	62·	1·79239	8·20761
Phosphorus Acid......	....	$H_3\ O_3\ P$	82·	1·91381	8·08619
Anhyd..	....	$P_2\ O_3$	110·	2·04139	7·95861
Chloride	4·742	$P\ Cl_3$	137·5	2·13830	7·86170
Phosphoric Anhyd...	....	$P_2\ O_5$	142·	2·15229	7·84771
Chloride...	....	$P\ Cl_5$	208·5	2·31911	7·68089
Metaphosphoric Acid	....	$H\ O_3\ P$	80·	1·90309	8·09691
Orthophosphoric "	....	$H_3\ O_4\ P$	98·	1·99123	8·00877

(To be continued.)

* Vapor.

F. ZÖLLNER; ON THE TEMPERATURE AND PHYSICAL CONSTITUTION OF THE SUN.

[Report of the Royal Saxonian Scientific Association. Mathematical and Physical Class. Session of the 2d of June, 1870.]

LEHIGH UNIVERSITY, *Sept.* 15, 1870.

To the Editors of the Journal of the Franklin Institute.

GENTLEMEN:—Quite recently I have received from my friend, Prof. Zöllner, an important memoir "On the Temperature and Physical Constitution of the Sun," a translation of which I forward you for publication in the *Journal of the Franklin Institute*, which has ever kept us so well informed of all that relates to solar physics.

Prof. Zöllner's memoir accompanied the following letter:

"LEIPZIG, *July* 30, 1870.

TO PROF. A. M. MAYER, PH. D.

"MY DEAR SIR:—I have waited until to-day to fulfill the duty of answering your agreeable letter and tendering my thanks for the reception of the reports of your investigations. I hope you will excuse my delay. It was my intention to reciprocate your favor by sending you the accompanying report, the completion of which required a longer time than I had originally supposed.

"At the present time, when Germany is arming for a struggle of life and death, and when the waves of national enthusiasm surge even into the quiet workshops of science, successful investigations are out of the question. I am, therefore, doubly glad that I have finished the present work before the beginning of the great catastrophe. It contains a sketch and the principal points of a longer, separate treatise upon the sun, which was to follow this report in a few months. Under the existing circumstances, however, I will probably want the necessary repose to finish it in so short a time.

"Receive the assurance of my especial esteem and favor again, with a few lines.

"Yours, sincerely, F. ZÖLLNER."

I.—AMONG the characteristic shapes of the protuberances,* which can now be observed at any time with a spectroscope having a widened slit, there is a considerable number which must convince

* The forms of the protuberances may be divided into two characteristic groups: *vaporous* or *cloudy* and *eruptive*. The preponderence of one or the other type seems to depend partially on local conditions of the solar surface and partially on

every unprejudiced observer that they are due to violent eruptions of incandescent hydrogen.

It is impossible, without passing beyond the well-known analogies necessary for the explanation of cosmical phenomena, to assign any other cause to these eruptions than the difference of pressure of the gases emanating from the interior and from the surface of the sun. To make such a difference of pressure possible it is necessary to admit the existence of a separating stratum between the inner and outer strata of hydrogen—the latter of which, as is well known, forms an important portion of the solar atmosphere.

The admission of this separating layer seems inevitable at the first sight of the protuberances, even to those observers who, like Respighi, do not deem it improbable that these eruptions are due to electrical causes.

But if we retain the more simple, and, therefore, more natural explanation by difference of pressure, we will be able to draw important conclusions in reference to the temperature and physical structure of the sun by following out the mechanical theory of heat and of gases.

From the premises of the mechanical theory for unliquifiable gases follow:

1. Marriotte's and Gay Lussac's Laws.

2. The constancy of the relation of specific heats under constant volume and constant pressure.

This constant quantity, determined for a certain gas by well-known methods, must be considered as invariable (like the atomic weight of a body), according to the mechanical theory of gases, and must not be classified with other empirical constants, such as the power of conducting heat, or the coefficient of expansion of solids and liquids. These constants are true only within the limits for which they have been ascertained by observation, and lose their significance if these limits are considerably exceded.

According to this assumption, I consider the eruptive protuber-

the time, so that at certain times one or the other type may preponderate. The fact that the cloud-like formations remind us so vividly of terrestrial clouds and vapors is easily explained, if we consider that the forms of our clouds are not due to the vesicles of water suspended in them, but to the manner in which heated air in motion expands.

The vesicles of vapor in terrestrial clouds only form the means through which the above-mentioned differences of masses of air become visible. The clouds of the protuberances are made visible by the incandescence of glowing hydrogen.

ances as a phenomenon, due to the flow of a gas from one space into another, while the pressure in both is constant, and neither communication nor absorption of heat is assumed.

Let A = the equivalent of heat for a unit of work;
v = the velocity of the flow of the gas in the plane of the opening;
g = the intensity of gravitation on the sun;
x = the relation of the specific heats of the gas under constant pressure and constant volume;
c = the specific heat of the gas under constant volume, in its relation to an equal weight of water;
t_i = the absolute temperature of the gas in the inner space from which it emanates;
t_a = the absolute temperature of the emanating gas in the plane of the opening through which it flows;
p_i = the pressure of the gas in the inner space;
p_a = the pressure in the plane of the opening.

According to the mechanical theory of heat these nine magnitudes bear to each other the following relations:*

$$A\frac{v^2}{2g} = x\,c\,(t_i - t_a), \qquad \ldots \qquad [1.]$$

$$\frac{t_i}{t_a} = \left(\frac{p_i}{p_a}\right)^{\frac{x-1}{x}}, \qquad \ldots \qquad [2.]$$

Furthermore, let a_1 = be the mean height of the barometer in mètres of mercury;
ρ = the density of the gas at the temperature of melting ice under the pressure of the column of mercury a, and on the surface of the earth;
σ = the density of the gas in the inner space under the pressure p_i and at the absolute temperature t_i;
α = the coefficient of expression of the gas for 1° C.

According to Marriotte's and Gay Lussac's Law, we have—

$$\sigma = \frac{\rho}{a_1\,\alpha}\cdot\frac{p_i}{t_i}, \qquad \ldots \qquad [3.]$$

The pressure p_a in the plane of emanation may be considered

* Zeuner, Elements of the Mechanical Theory of Heat. Second edition: 1866, p. 165.

equal to the pressure of the solar atmosphere at the level of the above-mentioned separating stratum (*i. e.* at the base of the atmosphere). Then let

p_a = be the pressure at the base of the atmosphere;
h = a certain height above the base;
p_h = the pressure at this height;
t = the absolute temperature of the atmosphere assumed as constant—the law of temperature not being known;
g = the gravity of the sun at the base of the atmosphere;
r = the radius of the separating stratum;
ρ_1 = the specific gravity of mercury at the temperature of melting ice;
g_1 = the intensity of gravity on the surface of the earth;
a_1 = the mean height of the barometer;
ρ = the density of the gas of the atmosphere at the temperature of melting ice and under the influence of the magnitudes g_1 and a_1.

Then we have by a well-known process:

$$\text{log. nat.}\left(\frac{p_a}{p_h}\right) = \frac{\rho\, g\, r\, h}{\rho_1\, g_1\, a_1\, at\, (r+h)}, \qquad . \quad . \quad . \qquad [4.]$$

In order to combine this equation with the three preceding ones we must assume:

1. That the principal component of the solar atmosphere, which produces the pressure p_a, consists of the same gas which emanates from the interior of the sun to form the eruptive protuberances.

2. That the absolute temperature t, of the atmosphere is equal to the absolute temperature t_a, at the plane of the opening through which the gas passes.

The first of these assumptions I consider amply justified, because the discovery of the so-called chromosphere furnishes the proof that the whole surface of the sun is actually enveloped by a considerable atmosphere of hydrogen.

I am led to the second assumption by the fact that there is scarcely any difference in the brilliancy of the basis of all eruptive protuberances from that of the chromosphere. If we consider, moreover, that the constant mean temperature t, in formula [4], which has been substituted for the temperatures decreasing for the

height h (because the law of the decrease is not known), must correspond to that of a stratum near the base,* then this temperature approaches that of the outer surface of the separating stratum.

According to the first supposition, ρ in formula [4] becomes identical with that in [3], and according to the second

$$t = t_a.$$

II.—After explaining the theoretical principles necessary to the consideration of the solar phenomena, we will now simplify the above equations.

If H is the height to which a body will ascend perpendicularly with an initial velocity v on the surface of the sun, we have, considering the decrease of gravity:

$$v^2 = 2\, g\, H \frac{r}{r + H},$$

or,

$$\frac{v^2}{2\, g} = \frac{r\, H}{r + H}.$$

Substituting this value of $\frac{v^2}{2\, g}$, in formula [1], we have

$$t_i = \frac{r\, H\, A}{x\, c\, (r + H)} + t_a\,;$$

or if $\frac{r\, H\, A}{x\, c\, (r + A)} = a$, and according to our supposition $t_a = t$, we get for formula [1] $t_i = a + t$. . . . . [I.]

Then let $\frac{x - 1}{x} = \frac{1}{q}$, $\frac{\rho}{a_1\, a} = b$ and $\frac{g}{g_1\, \rho_1} = m$. Then will formulas [2], [3] and [4] become

$$\frac{t_i}{t} = \left(\frac{p_i}{p_a}\right)^{\frac{1}{q}} \quad . \quad . \quad . \quad . \quad . \quad \text{[II.]}$$

$$\sigma = b\, \frac{p_i}{t_i}, \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{[III.]}$$

$$p_a = p_h\, e^{\,b\, m \frac{r\, h}{(r + h)\, t}}, \quad . \quad . \quad \text{[IV.]}$$

* In reference to the increasing density of the air towards the base, the temperature in formula [4] (independently of the special law for decrease of temperature), must correspond to the temperature of a layer which is *lower* than $\frac{h}{2}$. This difference, which is generally very considerable, as is shown by a simple calculation, seems to be generally neglected in determining heights by the barometer (in which the mean temperature of the two stations is used); and this circumstance seems to explain periodical phenomena, observed lately, in a very simple manner.

From these we obtain by elimination:

$$\sigma = \frac{b\, p_h}{a+t} \left(\frac{a+t}{t}\right)^q e^{b m \frac{r h}{(r+h)\, t}}, \quad . \quad . \quad . \quad [\text{V.}]$$

This equation, therefore, expresses the density σ of the compressed gas only as a function of the three magnitudes p_h, h and t. If, therefore, under the above suppositions, we can determine three of the four magnitudes by observation or keep them within limits, we can obtain the fourth. Now, by means of spectroscopic and other observations σ, p_h and h can be actually determined within certain limits, so that we may also limit t, the temperature of the outer hydrogen atmosphere near the glowing liquid separating stratum. Substituting this value in [I.] (H being known), we obtain a value for the inner temperature t_i, and [III.] and [IV.] also yield values for p_i and p_a.

III.—In the discussion of numerical values, I will begin with formula [I].

The lowest value assignable to t is, of course, 0. Then t_i becomes a minimum:

$$t_i = a = \frac{r\, H\, A}{x\, c\, (r + H)}, \quad . \quad . \quad . \quad . \quad . \quad . \quad [5]$$

On account of the fact that the density of the atmosphere almost becomes zero, even at a moderate distance from the surface and the resulting slight resistance, H may for simplicity be made equal to the mean height of the protuberances. The conditions necessary for this will be discussed further on.

Not unfrequently the protuberances attain the height of 3 minutes. In order to keep within the bounds of a mean value, I will take H at 1·5 minutes. Assuming the metre and degree centigrade as units, the equivalent of heat $A = \frac{1}{424}$. The product, $x\, c$, according to the latest researches of Regnault (*Pogg. Ann.* 89 vol.) equals 3·409 for hydrogen. According to Dulong (*Ann. de Chem. et de Phys.* t. 41) the value of x for hydrogen equals 1·411.

The numerical value of r requires a somewhat longer discussion. This is the radius of the separating stratum, from which the protuberances emanate. Here the question arises whether this value coincides with that of the solar radius, *i. e.*, whether this stratum coincides with the boundary of the luminous solar disc used for our measurements.

The latest investigations of Frankland and Lockyer, St. Claire-

Deville and Wüllner have proved that the broken spectrum of hydrogen and other gases may be changed to a continuous brilliant one by increasing the pressure. When this is done the bright lines of the broken spectum undergo very characteristic changes, which consist principally, as in the line $H\beta$, in a widening and increasing blurring of outline.

From these changes we may, within certain limits, draw conclusions concerning the amount of pressure, as Frankland and Lockyer have indeed done. They believe "that at the lower surface of the chromosphere itself the pressure is very far below the pressure of the earth's surface."

The investigations of Wüllner, I believe, even justify the assumption that the pressure at the base of the chromosphere or at the extreme edge of the luminous solar disc must be between 50 mm. and 500 mm. of a mercury barometer on the earth's surface.

For this reason the presence of dark lines in the solar spectrum on a continuous ground does not necessitate the assumption that this continuous spectrum is caused by the incandescence of a solid or liquid; for we may with equal right assume that it is due to the incandescence of a more highly compressed gas.

Wüllner has even proved this experimentally for the sodium-line, and he makes the following observations:

"At a pressure of 1,230 mm. the maximum at $H\alpha$ falls back still further; the whole spectrum becomes dazzling, and the sodium-lines appear as beautiful dark lines;* a proof that the light of hydrogen is intense enough to produce a Fraunhofer's line in an atmosphere of sodium, and that the light of an incandescent solid is not necessary."

It follows from this that the radius of the visible solar disc is not necessarily identical with that of the assumed separating stratum, but that the latter probably lies below that stratum, where the spectrum of the hydrogen atmosphere becomes continuous by increased pressure. This view is supported by the appearance of solar spots.

Nearly all observers, however different their theoretical opinions about the nature of the solar spots, agree in that the nucleus of

* In consequence of the high temperature of the tube, sodium from the glass becomes vaporized. At a pressure of 1,100 mm. the sodium-lines are still bright, (l. c. p. 345.)

these spots must be deeper than their surroundings.† This depth is taken at about 8″, partially from direct (De la Rue, Steward, Lœwy) and partially from indirect observations (Faye).‡

If the nucleus of the solar spots is considered as a scoriaceous product of local cooling on a liquid surface, and the penumbræ as clouds of condensation, which surround at a certain height the coasts of these islands of slag,§ then the simplest supposition is that the liquid surface (necessary to support this theory) is identical with the surface of the separating stratum in question, from which the protuberances burst forth. If R represents the observed solar radius in seconds, then the radius r of this surface would be approximately,

$$r = \text{R} - 8''.$$

Or R at 16′ at the mean distance of the sun, $r = 15' \, 52''$.

If the mean parallax of the sun is taken at 8″·915, according to Hansen, then

$$r = 680{,}930{,}000 \text{ metres};$$
$$\text{therefore, } 8'' = 5{,}722{,}500 \quad ``$$

In order to determine numerically the absolute minimum temperature in the space, from which an eruption of 1·5 minutes height takes place, we must substitute the following values in fomula [5]:

$$r = 680{,}930{,}000;$$
$$\text{H} = 64{,}370{,}000;$$
$$\text{A} = \frac{1}{424};$$
$$xc = 3{\cdot}409.$$

Then we will find that

$$t_1 = 40690°.$$

If we substitute for H double the above value, which would cor-

† Spörer, however, says: We consider the spots as cloud-formations above the luminous surface of the sun. The penumbra is nothing more than an aggregation of small spots, the spaces between which allow the luminous surface to shine through, *above* which the spot is situated.—*Pogg. Ann.* vol. 128, (1866.)

‡ Faye, by computations based on the observations of Carrington, finds that this depth is 0·005 — 0·009 of the solar radius.—*Comptes. Rendus*, LXI., 1082—1090.

§ This theory has been indicated by me in my photometric observations, p. 245, five years ago, and further developed last year in the quarterly report of the *Astrom. Soc.*, year IV., No. 3, p. 172. I reserve a still further development and explanation by means of the spectroscopic observations on solar spots, for a paper soon to be published.

respond to a protuberance of 3 minutes height, then the minimum value of

$$t_1 = 74910°.$$

Here, however, the question arises, whether we have a right to substitute the extremes of the observed heights of protuberances in our formulæ for H, which stands for the distance to which a body, thrown up vertically from the sun, would rise without resistance. If we actually have to do with burning masses of hydrogen, as observation proves beyond a doubt, their rising may be due equally well to Archimedes' principle, like that of heated gases in a chimney, by becoming specifically lighter than the surrounding atmosphere. These two causes would, however, differ materially in the *time* necessary for the gaseous masses to reach a certain height. Without entering into a special discussion of this point, it is clear that the time needed by a protuberance to rise to a given height, by Archimedes' principle, must in all cases be greater than by a force throwing it vertically up to the same height without resistance and with a certain initial velocity.

Therefore an observation made as accurately as possible on the time required by a protuberance to reach a certain height will decide whether this height is due to the former cause, and in that case only can the light be used as an integrating component of the above formulæ.

(To be continued.)

Bibliographical Notices.

Laboratory Teaching; or, Progressive Exercises in Practical Chemistry. Prof. Bloxam. London: Churchill & Son, 1869.

The author, in this compact little manual, has followed a plan different from that of most works on Qualitative Analysis, and one better calculated to familiarize the learner with the appearance, detection and properties of the most important chemical bodies. Instead of a long introduction, in which the preparation and impurities of the re-agents are treated of, and the re-actions of all the metallic and non-metallic substances, (a very thorough course, but one which experience shows, too often wearies the beginner, and

induces him to abandon the study,) these matters are presented where, in the progress of his study, a curiosity shall have arisen in the mind of the student concerning them. The directions for analysis are supplied in the form of tables, with references to passages explanatory of the requisite processes. After each table an account is given of the bodies referred to in it. In this way the student is induced to make himself acquainted with the common chemical substances. Otherwise, as too frequently happens, he may be able to make a correct analytical determination of the acid, base or other constituent of a compound, and yet may be altogether ignorant, or fall into the most absurd mistakes as to what this compound actually is. The increasing number of organic compounds, and their growing employment in the arts, has necessitated the extension of the methods of qualitative analysis to them, and this need has been fully recognized and met by the author. A large number of tables and directions will furnish the student the string by which he may be able to make his way in the labyrinth of chemical compounds, and seize upon the substance he is searching after.

A Cyclopædia of Quantitative Chemical Analysis. By Frank H. Storer, A.M., Professor of General and Analytical Chemistry in the Massachusetts Institute of Technology. Part I. Sever, Francis & Co. Boston & Cambridge: 1870.

Prof. Storer has undertaken the task of compiling in convenient and manageable form, an encyclopædic history of quantitative chemical processes, and to judge from so much of the work as has already appeared, his undertaking will prove eminently successful. The plan adopted, is one which must commend itself to the working chemist, as the most simple, and at the same time, the most philosophical that could have been chosen. It is the system of classifying substances in alphabetical order, and of referring each and every process to the fundamental fact or principle upon which it depends for its efficiency. This classification renders the material readily available for reference, while the descriptive portions of the work are detailed enough to leave little or nothing more to be desired in that direction.

It deserves to be mentioned also that an excellent selection of examples for students will accompany the encyclopædic matter. The work of Prof. Storer will find a ready welcome and a familiar corner in the laboratory.

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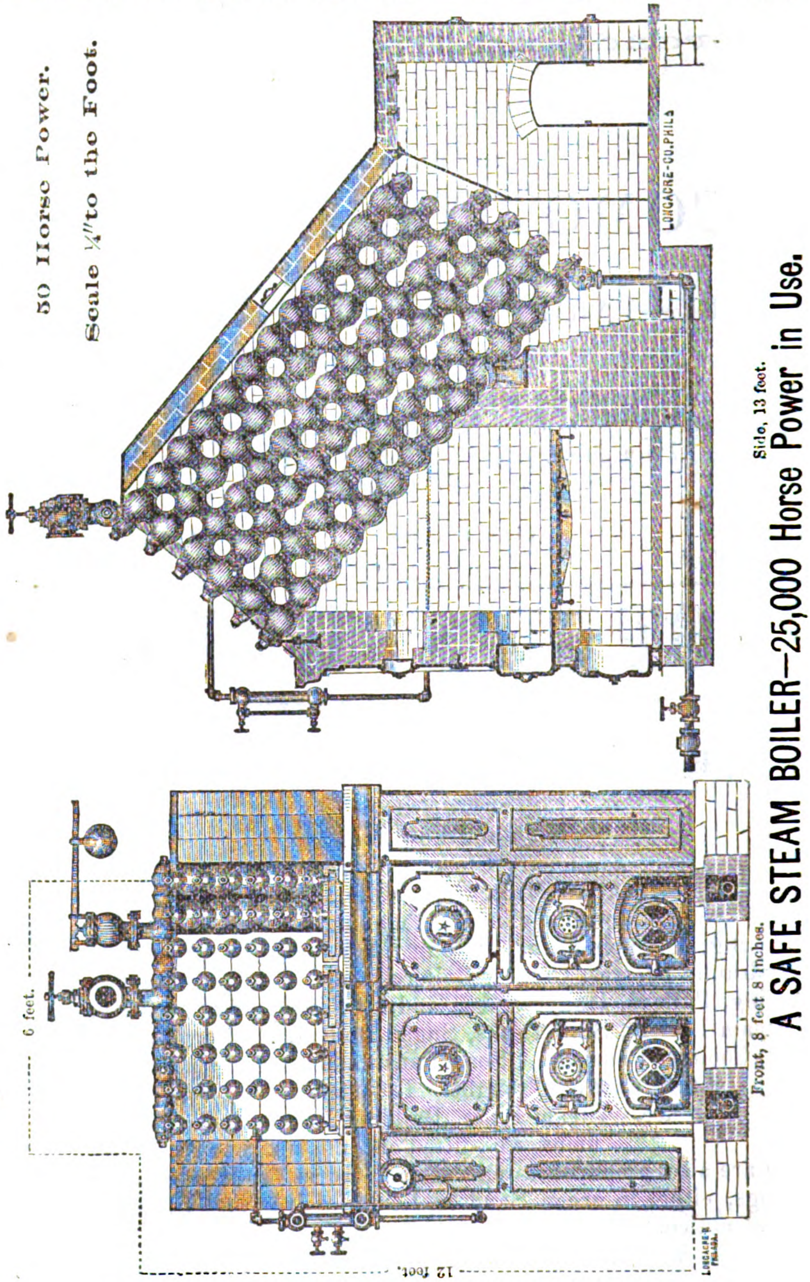

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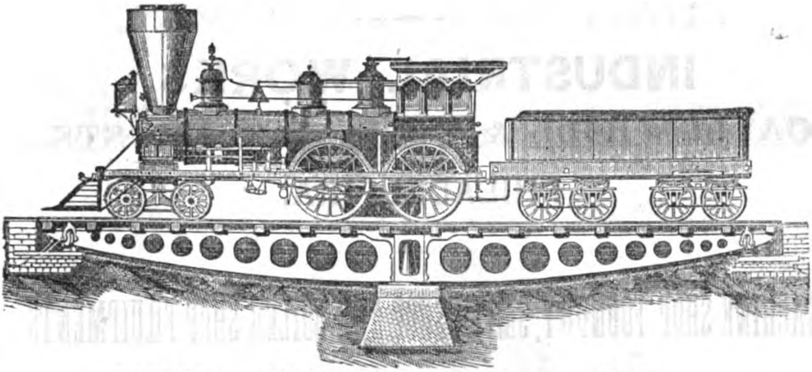

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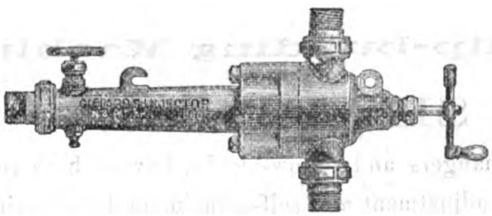

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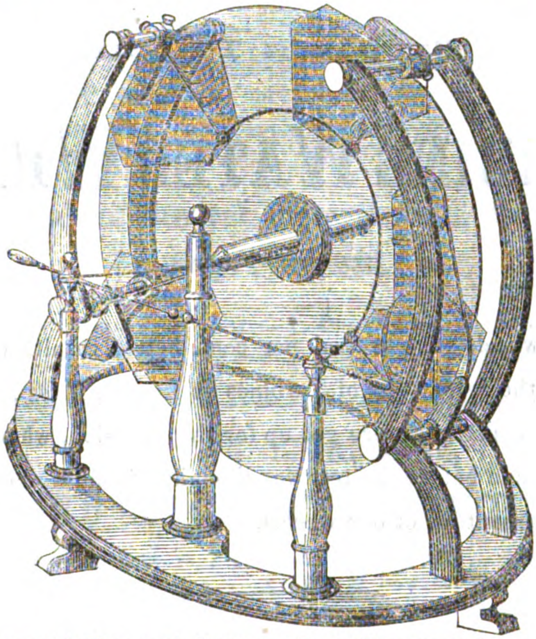

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EDITORIAL.

ITEMS AND NOVELTIES

Disburdened Valves.—Philip Mayer.—The following, from the *Zeitschrift des Oester. Ing. Vereins*, may prove of interest:

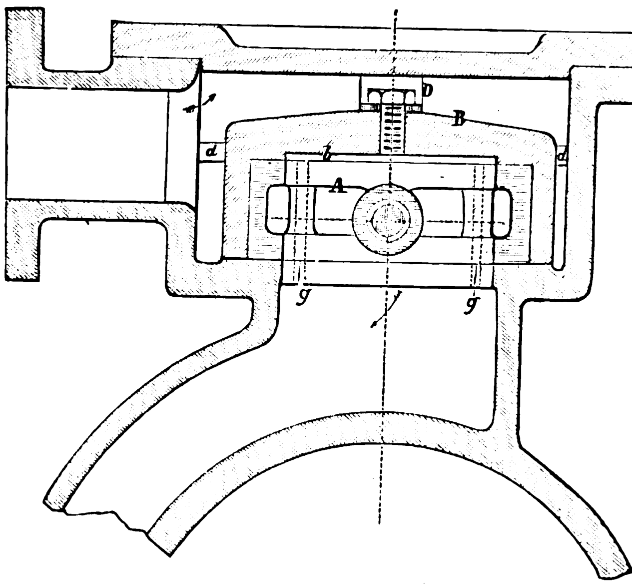
The modes of construction of disburdened valves which I propose here to describe have proved themselves of the greatest merit.

Figs. 1, 2, 3 represent Nasmyth's valve, the simplest of its class and yet satisfactory. The disburdening arrangement consists of a cover which surrounds the valve on three sides, and receives the pressure of the steam, so that the valve slides between this cover and the port face on the cylinder, without the slightest friction caused by steam pressure.

a, *a* and *b* are the steam passages, arranged in the usual way. A is the valve open above. B the cover lying loose in the valve-box, and only prevented from displacement by the projections *d*, *d*, *e*, *e*. The length of the cover equals that of the valve and its stroke.

If now the valve A has its upper and lower faces smooth and parallel, and if the inner face of the cover and the port face on the cylinder be smooth and parallel also, and be a distance asunder absolutely equal to the opposite faces of the valve, no pressure can be exercised on the valve itself, providing the cover is strong enough to resist the superincumbent pressure of steam upon it. That such a valve can be made in practice is a matter of certainty.

Fig. 1.



Such a valve, however, would not be disburdened in every position, since at the moment the steam port was partly opened, as also during the period of compression therein, a pressure from within would be exercised upon the valve which would not be counterbalanced.

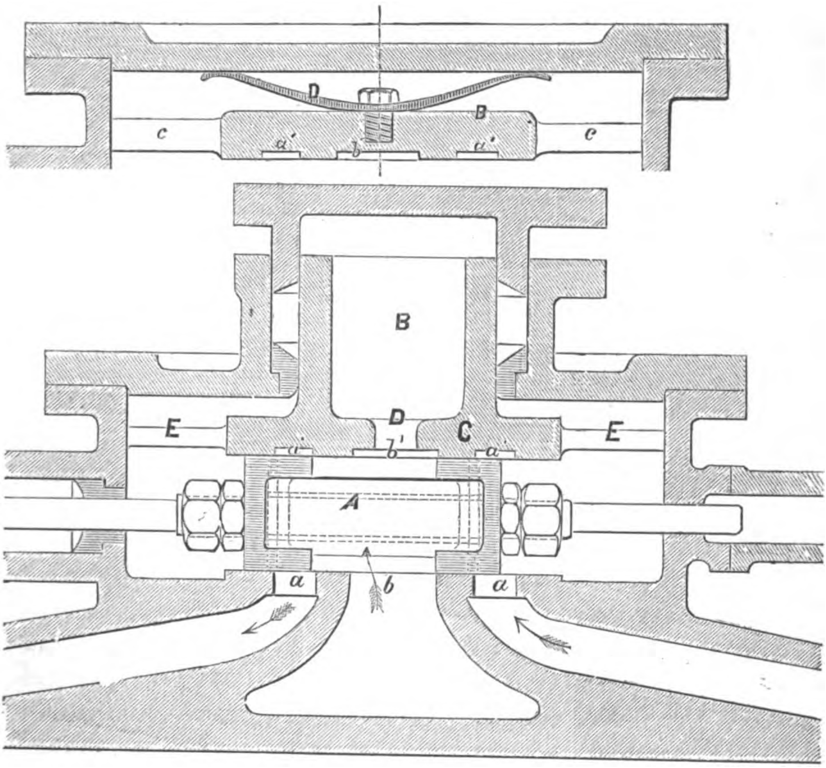
In order that the valve shall be completely disburdened in every position, openings a' a' b' are made in the cover exactly opposite, and of equal dimensions with a a b; in addition to these drilled passages, g g g g are made in the ends of the valve, as shown, by means of which not only the inner and outer surfaces of the valve communicate with each other, but also with the steam passages and the opposite openings a' a' b'.

From this arrangement of parts it is apparent that the steam will

play symmetrically about both ends of the valve, and that the pressure exerted upon one side will be counterpoised by a similar pressure upon the other, so that the valve is disburdened in every position.

The spring, D, attached to the cover, serves merely to protect the cover from accidental displacement.

Figs. 2 and 4.



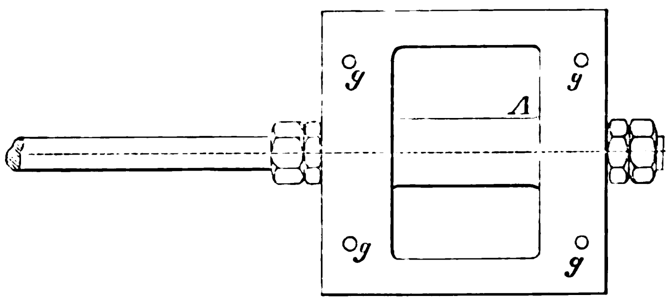
I have frequently tested this valve under a hydraulic pressure of 20 atmospheres and upwards, and on one occasion exposed it to a pressure of 40 to 50 atmospheres, when it could be moved easily by hand.

The second disburdened valve I will mention was constructed by myself in 1859. In the conception of this form of valve I proceeded upon the principle that the disburdening should not be accomplished by screws, nor by any other mechanical contrivances,

all of which are necessarily imperfect, but that it should be accomplished entirely by the steam itself.

This I do by introducing the steam through the ordinary exhaust port, *b*, to the interior of the valve, thence to the steam passages, and finally allowing it to escape through the valve-box to the atmosphere, which corresponds to a valve position, altered by 180° from the ordinary excentric place on the shaft.

Fig. 3.



The valve A, Fig. 4, is not closed above, and upon its upper side rests a cover plate, C, which passes into a cylindrical adjoining piece, B; the cover plate is of the same length as the valve and its stroke, so that the valve is always covered.

The plate C has an opening, D, through which the cylindrical portion, B, is kept in constant communication with the steam chamber, by which means the steam can press equally upon both sides of the valve. The cover is furnished, opposite to the steam passages, with openings and with distance pieces, E E, similar to those in the valve first described.

In this valve the friction and wear of the valve stem is less than in the other, because it works in exhaust steam, and it may be applied to existing engines by changing the steam and exhaust pipes, putting one in the place of the other.

[WE TAKE pleasure in calling the attention of our readers to the following communication from an esteemed correspondent, believing that its importance merits the widest circulation, and the heartiest co-operation of those to whom it is especially addressed.—*Eds.*]

A Word to Engineers, Machinists, Millwrights and Manufacturers.—Answers to the following questions are solicited by the subscriber, for the purpose of getting a wider range of facts and fig-

ures about belts for driving machinery, than can be obtained from the ordinary sources of such information, from which have already been compiled a series of facts, in condensed form, occupying over a hundred pages in the *Journal of the Franklin Institute*, and extending over two years of time.

Much interest is felt among engineers to make this series of facts complete, to accomplish which, full and exact replies to the following questions will be needed and will be thankfully received.

As all the information collected will be published in the current numbers of this *Journal*, which are accessible to all, it is believed that those who give will also receive.

JOHN H. COOPER, Peoples' Works, Philadelphia.

1.—What is your rule for calculating the horse-power of a belt?

2.—How many pounds of adhesion or driving-power do you allow for one inch width of belt?

3.—What are the relative economic values and adhesive values of single-leather, double-leather, gum and paper belts, when used under like circumstances?

4.—Does the area of contact determine the driving-power of a belt?

5.—What are the relative adhesive values of round and of flat leather belts?

6.—Give the tensile strength of belting, leather, vulcanized gum and paper belting?

7.—What are the relative tensile strengths of laced, riveted and cemented joints, as compared with the material of the belt so joined?

8.—What is the best method of joining the ends of a belt, considering economy and convenience?

9.—What is the best material or composition for preserving belts and keeping them in good working condition?

10.—What material will give belts most adhesion without permanent injury to them?

11.—Which side of leather belts should run next to pulleys to secure the greatest economy in their use, and which side will drive most?

12.—If a belt be split through the middle of its thickness, which half will sustain most weight, and how much will each sustain?

13.—Are thick or thin belts best for transmission of power?

14.—How much convexity per foot of face should pulleys have?

15.—What speed is best for belts, considering the length, size and kind?

16.—What effect has centrifugal force on the driving-power of high-speed belts?

17.—What are the best working limits of belt length, distance between shafts, size of pulleys and belts?

18.—How much speed is lost in the transmission of power by belts; give the loss by slip and the loss by elasticity of belts: of leather and of gum?

19.—What are the relative values of rough iron, smooth iron, leather-covered, gum-covered and of wooden pulleys: also, what is the most adhesive wood for pulleys?

20.—What way is best to fasten leather to metal?

21.—What is the proper allowance of belt for cog-gear in order that each may be equal to the other in durability; the belt enveloping half the pulley, of single leather, and all the parts in good working proportions and condition?

22.—If possible, give the values of w in inches, in the formula: $w = pf$; in which $w =$ width of single leather belt in inches, and p and $f =$ pitch and face of gear in inches. All the terms should be derived from machinery in use, and particulars given, observing also that w gives the effective belt width at the pitch line of the teeth.

23.—Give the particulars of any high-speed belts with which you may be familiar, more especially of the loss of driving-power due to velocity.

24.—Give any other facts and figures in relation to belts with which you may be acquainted?

Removal of the Hell Gate Obstructions.—The work of removing these noted obstructions to navigation is continued unremittingly night and day. Eight "galleries" or chambers have been commenced. These run in various directions—under the reef—all converging to a common centre at the point of beginning. They are named after distinguished men. Those furthest advanced are "Grant," "Sherman," "Humphries." They all front the great excavation, which is 60 by 100 feet in size, and 30 feet from the mean low-water mark to the floor line. "Grant" gallery has been pierced to a distance of 32 feet directly under the most formidable spur of the reef. These tunnels are to be extended a distance of 200 feet, and are from eight to ten feet in diameter. The rock is very hard—mostly gneiss. The blasting charges are one-quarter, one-half, one and two pounds respectively, contained in paste-board tubes well wrapped in glazed gutta-percha cloth, tarred at the ends, with safety-fuse, all water-proof. Thirty or forty of these are discharged at the same time, a gong being previously sounded to draw off the workmen.

Huge logs, interlaced with iron bands, form "curtains," which are hung at the opening of each tunnelling to prevent the detached rock from being hurled into the air without. The force is so terrific, however, that these ponderous curtains are often swung out eight or ten feet. Great steam derricks elevate the refuse, and steam pumps lift out the water. Daily observations are taken to guide the work. A miniature levee keeps off the water on the river side. A temporary platform extends out over the reef, from which a fine view of the wild, rushing tides is afforded. Even when but about a depth of two feet of water is flowing over the "hog's back," its force is so great as to sweep a strong man instantly off his feet. This gigantic enterprise must proceed very slowly, and require years for its successful consummation.

The Broadway Underground Railway commences at the foundation lines of the splendid marble building on the corner of Warren street, and extends in a curve directly down Broadway. The lower terminus is intended to be at the South Ferry; but the present operating section only extends a little below the City Hall, near to the north end of the new post-office premises, a distance of some three hundred feet.

The bed of the railway is 21 feet below the surface of Broadway, and the diameter of the tunnel 9 feet. The passenger car is about the same size as the ordinary street ears. It is very tastefully fitted up, brilliantly lighted, and has seats for twenty-two persons. It is propelled by the atmospheric system; that is to say, by means of a strong blast of air which is supplied to the tunnel by a gigantic blowing machine.

The whole operation is described as being exceedingly simple and effective. The visitor enters at the corner of Broadway and Warren street, descends a few steps to the waiting-room, an elegant apartment, but wholly underground, at the end of which is seen the mouth of the tunnel and the car. On taking seats in the car, the conductor closes one of the doors and touches a telegraph signal, when the car immediately begins to move around the curve, and travels rapidly down Broadway. On reaching the lower end of the tunnel, the car moves instantly back again to Warren street, then down Broadway again, and so on. The air is so elastic that the changes of motion in the car are effected with exceeding gentleness, and are almost imperceptible to the visitor.

The car is run by telegraph; that is to say, the wheels of the car, at certain points on the route, press a telegraph key, sending a signal to the engineer, who turns a valve and thus reverses the air current, without stoppage of the machinery.

The Aeolor or blowing machine by which the air current is produced consists of a pair of great wings, geared together, and turned by steam. It is capable of discharging 100,000 cubic feet of air per minute, or enough to fill the interior of three three-story city dwelling-houses.

The south end of the tunnel is provided with a lateral air shaft, which opens in the grass-plot of the City Hall Park. The air current thus traverses through and through the tunnel, the atmosphere of which is thus kept pure and fresh.

During the construction of the tunnel the entire travel of Broad-

way, omnibuses, carts, hacks and other vehicles, in endless procession, passed on as usual, directly over the heads of the workmen. They were safely protected within the sides of an immense boring machine, by which the bowels of the street were excavated. It is pushed forward into the earth by means of powerful hydraulic rams; and as fast as it advances the masonry is built up within its rear.

The works of the Broadway Underground Railroad, taken altogether, are of a most interesting nature, well worthy of examination. The general plan of the Company is to lay a double line of tubes from the South Ferry, under Broadway, the entire length of the island; with a branch at Union Square, under Fourth Avenue, to Harlem river. Such a road would have capacity for carrying forty thousand passengers per hour.

Rotary Puddling Furnaces.—A number of puddlers of this character, have for some time been in successful operation at the Cincinnati Railway Iron Works, and have attracted considerable local attention.

The machine puddlers dispense with the hand labor of the usual furnaces, performing the same duty by steam-power. Those at present in operation, are making puddled balls of from 650 to 700 pounds in weight; and others of greater capacity are in process of construction. Samuel Danks, of that city, is the inventor.

T. du Motay's Oxygen Process.—In connection with the oft mooted question of the practicability of the general introduction of oxygen gas for illuminating and other purposes, it may not be uninteresting to give a description of this process, which, if it does not altogether obviate the practical impediments attendant upon the subject, is at least the nearest approach to a solution of the problem which has yet been presented for public approval.

The principle of the process resides in the fact that the manganates and per-manganates of potassa, soda and baryta, the Ferrates and Chromates of the same bases, and in general all metallic oxides or acids which will form with potassa, soda and baryta, binary compounds capable of superoxidising, possess the property of yielding their oxygen at a more or less elevated temperature when they are submitted to the action of a current of steam.

These bodies, thus deoxidized, also possess the property of reoxidizing themselves when they are exposed to the action of a current of air at a temperature more or less great. The atmosphere

is therefore the constant source from whence the oxygen is derived. The mode ef operation is the following:—One of the binary compounds just enumerated is placed in a distilling vessel, whether at the maximum or minimum state of oxidation. If the compound is in the latter condition, it is oxidized by means of a current of air mechanically drawn over it; if at the former stage, it is deoxidized by means of a current of steam.

The oxygen and the steam, on issuing from the mouth of the retort, pass together into a condenser, where the steam is separated by condensation, while the oxygen passes over into a gas holder, and is there collected.

When all the utilizable oxygen contained in the binary compound has been disengaged by the steaming process, the action of superoxidation by means of the air-current is recommenced.

By this alternate process the oxygen is generated as long as may be required.

The Technical Schools of Holland.—The following is an abstract of an article in a late number of *London Building News*:—

"There are admirable technical schools established in Italy, Austria, France, Germany, Belgium, Switzerland and Holland. The last named country presents special features of interest, for the reason that its endeavors in a manufacturing direction are of comparatively recent date, say within the last quarter of a century, and that its working classes were said to dispute with those of England the bad pre-eminence of being the worst educated in western Europe. Their works and railroads were made by English engineers, who took with them English workmen. After 1839 a change took place, and capitalists called home their foreign funds and invested them in home manufactures. But they could not find intelligent workmen at home and they employed Germany.

"This continued until 1848, when the social earthquake woke up Holland as well as other countries; new men came into power, and among other things new educational laws were passed, although the friends of ignorance made violent opposition. At present the secondary (or technical) instruction is regulated by the law of 1863.

"The schools consist of (*a*) Burger day or evening schools, intended for the working classes. These are mostly held in the evening, the boys being apprenticed as soon as they leave the primary schools. The course of study as regulated by law is mathematics, rudiments of theoretical and practical mechanics and machinery,

natural history, agricultural science or technology, according to the locality of the school, geography, history, the Dutch language, political economy, ordinary and rectilinear drawing, gymnastics, to which the local authorities may add modeling or the German, English or French languages. (*b*) higher Burger schools, for the education of masters, overseers, the commercial classes, and, in short, all who are not intended for the army or navy, or one of the learned professions. The course of instruction in these schools includes those of the previous class, and adds the subjects of mineralogy, geology, botany and zoology, with more extensive studies of history and political economy, the rudiments of commerce and book-keeping. Besides these there are (*c*) the agricultural schools in which science relating to agriculture takes a more prominent part, and (*d*) the Royal Polytechnic School of Delft, which fulfils the function of *an industrial university*, giving the most advanced instruction attainable, and from which the government architects, naval engineers, shipbuilders, mechanicians and mining engineers are chosen.

"The law provides that there shall be at least one of the class of Burger schools wherever the population exceeds ten thousand, and fifteen government schools at least in different parts of the kingdom. The schools in 1867 had about two thousand two hundred pupils, which was in about the proportion of one to every sixteen hundred of the population. The boys enter at the age of twelve or thirteen; at the Burger schools they stay two years; at the higher schools they stay from three to five years; and they may enter the Polytechnic schools after passing the examinations of the schools below, at eighteen or nineteen years of age. There is as yet but one girls' school at Haarlem.

"The society for promoting the interests of the working classes at Amsterdam was established in 1854, and is now under the patronage of H. R. H., the Prince of Orange. It classifies its labors under five divisions, namely:—

"First.—The scavenger's brigade, which undertakes the sweeping of the streets, &c.

"Second.—The benevolent fund for affording relief to disabled workmen, &c.

"Third.—The industrial schools for the sons of workmen.

"Fourth.—Lectures for the working classes. These were established in 1866. During the last winter a course of fourteen popu-

lar lectures was delivered to persons of both sexes in the Frascati Buildings. The number of the audience varied from 600 to 1000. The subjects embraced by the lectures were Physics, Political Economy, Moral Philosophy, Pedagogy, History, Literature, Music and the Fine Arts. In addition to these a course of four lectures on Natural Philosophy were delivered exclusively to workmen, the audience numbering about 400.

"Fifth.—The needle-women's employment division.

"The school for workmens' sons is the most interesting. It was established in 1861, and receives a subsidy from the city of Amsterdam. In the year 1866 his Majesty King William III. presented the school with a large and important collection of models, implements and tools. New buildings were erected in 1867, on which occasion there was a great manifestation of public sympathy in favor of the school, Prince Frederick and the government of the Province taking part in the proceedings. There are 125 pupils, of ages varying from thirteen to sixteen years, the sons of workingmen, and thirteen teachers. The course of study embraces carpentering, forging, turning, embossing, carving; rectilinear architectural, machine, ornamental and hand drawing, &c., knowledge of building materials, lessons in physics, algebra, mathematics and mechanics. They exhibit a large portfolio of drawings, architectural and shaded, illustrations of carpentry, proceeding from the simplest to the most complex combinations, and elevations and plans of buildings and details of work, which would not discredit any architects' office; then there are some cable chains made of wrought iron, and various iron implements from the hands of the boys; several articles turned in oak, portions of sash frames, and dove-tailed carpentry very neatly and creditably done, several carvings in bas-relief in oak, models of architectural details (full size) in clay, turned articles in polished wood, a model of a timber roof very neatly made, a portion of a carved stair, with dove-tailed joints, and many other articles showing very careful and systematic teaching and considerable manual aptitude on the part of such young boys. It is not proposed to make the instruction given in this school take the place of the experience gained in the workshop by an apprenticeship, but it is an excellent preparation for workshop life; and the youngster who goes into the workshop from such a school as this, with a systematic knowledge of the rudiments of his trade together with the intellectual requirements indicated by the drawings and

writings here shown, will not be a hinderer to be snubbed and treated as a "necessary evil," which our own apprentice too often is, but he will be able so to utilize his further experience, that he will turn out a finished workman, with whom, unless they take a leaf out of the book of his instructors, the artizans of other lands will find it difficult to maintain a competition."

Cause of the Phenomenon of Phosphorescence in rarified gases after the passage through them of an electrical discharge. In a most interesting paper upon the above topic, by M. E. Sarasin, containing a detailed account of a series of investigations made to verify the conclusions of Becquerel and others who had previously worked in this direction, considerable light is cast upon many hitherto doubtful points. Becquerel attributed the phenomenon to the presence of oxygen, either pure or in mixture, or even in combination with other gases, but gives no satisfactory explanation of this assignment. Morren, who took up the subject shortly afterward, denied that pure oxygen produced the phenomenon, and insisted that the presence of other gases, and particularly that of nitrogen, was necessary to produce it.

Sarasin's researches were made with great care with a variety of simple gases and compounds. They included, amongst others, oxygen, nitrogen, compounds of the foregoing, hydrogen, chlorine, iodine, ammonia, carburetted hydrogens, hydrochloric and sulphuric acids, and the conclusions reached by him, are concisely stated as follows:—

1st. That pure oxygen (by electrolysis of water) gives rise to the phenomenon of phosphorescence.

2d. That gases containing oxygen likewise produce it, whether they be pure or mixed with other gases or vapors.

3d. That the presence of oxygen is necessary for the occurrence of the phenomenon.

As the doubtful question as to whether the phenomenon was due to a chemical action was to be decided, apparatus designed expressly for the purposes of this investigation was constructed.

If the phenomenon was to be referred to a chemical action as its cause—a recomposition of the elements sundered by the passage of the discharge, it was natural to refer the action to the formation of ozone, and of this the most convincing proofs were furnished by Sarasin's labors. In the experiments with pure oxygen, a substance possessing the property of readily absorbing ozone, (silver by for-

mic acid) was placed in contact with the rarified gas, so that as rapidly as ozone was formed by the spark it should be removed. The finely divided silver was soon blackened, and it was noticeable that as soon as the absorption began, the phosphorescence of the gas notably weakened, and finally ceased to be visible, a proof that the two phenomena, the formation of ozone and phosphorescence, accompany one another.

It was of the utmost importance to solve this question with sulphuric acid, which of all the substances examined, phosphoresced most strongly. To this end the same process was resorted to, as had been tried with such success upon oxygen (the introduction of an ozone-absorbing medium). Upon the passage of the stream instead of the beautiful phosphorescence shown by the vapor under other circumstances, only a very weak and very pale light was visible, in no way comparable to it. Here, as with the oxygen, the silver powder completely, or nearly completely, destroyed the phenomenon, and as before, the powder was oxidized.

Hence the experiment proved two things:—the decomposition of the sulphuric acid by the current, and the production of phosphorescence by the nascent oxygen or ozone.

From these experiments the author is led to his fourth conclusion, namely:—

That the phenomenon of phosphorescence is due to a chemical action, upon the nature of which it casts much light.

The following may represent what takes place during the continuance of the phenomenon:—

The gas is decomposed by the current, the oxygen contained in it is partially converted into nascent oxygen, or ozone, throughout the entire mass of the gas. In this condition it has a very strong tendency to unite with the other elements present; and, indeed, as soon as the current ceases it unites with them. This re-combination of the nascent oxygen or ozone takes place with energy, and may rationally be supposed to be accompanied by a generation of heat, which in its turn brings about the phenomenon of light which we call phosphorescence.

On the Change in the Radiation of Heat by Roughness of Surface.—One of the last papers by the late Prof. Magnus had the above title, and was published in *Poggendorff's Annalen.* It is one of great importance in some branches of art, and we shall give as full a summary of it as our columns will admit. He commences

his article with the statement that Leslie was the first to observe that a body with a rough surface radiates more heat than a body with a smooth one, and he thought this was conditional on the density of the surface, yet, he urged against this view the circumstance that the limit between hard and soft bodies cannot be fixed. Melloni subsequently maintained that the altered radiation depended merely on a change in the density of the superficial layer. In support of this view Melloni adduces the fact that in certain substances, such as glass, marble, agate, he found no change in the radiation, whether the surface were rough or polished, and only in the case of metals was there an increase when they were roughened. He ascribes this difference to metals being compressible, and that metal plates made by rolling or hammering have a greater density on the surface than in the interior. Looking at a list of radiating powers of bodies, it is at once seen that in general this property is inversely, as their respective densities, and as the different densities of one and the same substance. In support of this view he made the following experiment:—He constructed a quadrangular box with a metal bottom, using for its sides four plates of silver, two strongly hammered and two cast, and allowed to cool very slowly in their molds of sand, and, in order not to alter the density of the plates, they were polished with pumice-stone and charcoal, without the use of the hammer or burnisher; then they were joined together and to the bottom by means of soft solder. The outside of one of the cast and one of the hammered plates was then strongly rubbed in one direction with coarse emery paper. The sides which retained their lustre reflected sharp images, the rubbed sides dull and streaked ones. The silver vessel thus prepared was filled with hot water and the radiation of heat therefrom reaching the thermoelectric pile, the deflections of the needle were for the hammered and polished side 10°; the hammered and scratched side 18°; the cast and polished side 13·7°; the cast and scratched side 11·3°. Scratching the hammered plate had thus produced an increase of radiation, while in the cast plate it had produced a diminution. This unexpected fact appeared to Melloni to prove the correctness of his principle. We are as much and perhaps more justified in saying that the surface becomes denser by scratching, than in saying with Melloni, that it becomes less dense; for during the scratching a pressure is exerted upon the surface; and if even it be asserted that the individual scratches are not pressed in but are scooped out

in this scooping, a pressure is exerted upon the adjacent parts, which, even though exerted laterally, must necessitate a condensation. Prof. Magnus alludes to other experiments made by Melloni and Knoblauch which seem to confirm Melloni's views, and then gives experiments made by the author with platinum plates instead of copper and other easily oxidizable metals, so that other alterations also on the surface, such as are produced on silver by small quantities of sulphuretted hydrogen, were not to be feared. A platinum plate made as hard as possible before rolling, after having been heated, radiated as much heat as before. Here hardness cannot have affected radiation. Another platinum plate had been passed under very great pressure between two rollers, one of which was finely grooved; so that after this treatment one of the sides exhibited small elevations while the other remained smooth. The first radiated slightly more than the other; but after the plate had been strongly heated, even this difference was no longer perceptible. Hence it follows that when surface is otherwise the same, inequalities, and even regularly alterating elevations and depressions may exist without any increase in the radiation. When, on the contrary, a plain platinum plate, which had been heated by a glass-blower's lamp and was quite soft, was roughened by means of fine emery paper, the radiation was doubled. When a platinum plate was covered with a thin plate of spongy platinum, by spreading a thin layer of ammonio-chloride of platinum upon it, and then strongly heating, without treatment with nitric acid, it indicated seven times as much radiation as before being treated with spongy platinum. The author concludes that the increase of radiation with a roughened surface depends essentially on the refraction which heat experiences on its emergence from the surface of a radiating body. The greater the refractive index of heat between the radiating substance and the air, the smaller is the radiation from the plane surface, and then the quantity of heat reflected inward increases. The metals have doubtless a very high refracting index. Hence they reflect the rays from without and allow but few to penetrate, and hence they reflect internally those coming from the interior, and allow but few to emerge. Great inequalities of radiating surface do not occasion any important alteration in the radiation. Such a one only occurs when the radii of curvature are very small and change greatly, and when the radiating surface has but little diathermancy. In general, the roughness of the surface may effect

both an increase and a diminution in the radiation; but if the inequalities are very fine and very deep, there is almost always an increase in substances like metals. When there is a very fine powder of the same substance on almost any radiating surface, the radiation is considerably increased.

Luminosity of the Water Hammer.—A memoir by Prof. Lommel contains the account of a series of experiments made with the view to ascertain whether the instrument known as the water hammer (in this instance constructed of glass tubes of from 15 to 23 centimetres length, by from 15 to 20 centimetres width, and provided on one end with a bulb of about 4 centimetres diameter, the tube being partly filled with pure water, freed from air by long continued boiling,) would, when electrified as Geissler's tubes, produce phenomena similar to the latter when electrified. The author found that the water hammer acts in a very similar manner as do the Leyden jars, which are connected with the conductors of electric machines (*influens maschine*) for the purpose of obtaining stronger parts; moreover, the tubes alluded to exhibited brilliant luminous phenomena.

Journal of the Franklin Institute.—January, 1868.—The demands for sets of the *Journal* have recently been so great as to cause a serious diminution of the stock on hand. Especially does the management feel the want of the number heading this notice. In view of this fact we are prepared to pay 50 cents for every unmutilated copy of that number which is sent to the Hall of the Institute; and we would respectfully request of any of our subscribers who may have a knowledge of the existence and whereabouts of incomplete volumes to aid us in enlarging our stock of the wanting number.

Repairing of Porcelain Evaporating Dishes.—Dr. Waltt recommends the following plan as efficient in accomplishing this much to be desired achievement:

The vessel is first to be dried thoroughly, and then filled with a concentrated solution of silicate of soda, which is to be left upon the vessel for twenty-four hours after the liquid has been poured off; the same is now to be gradually dried over a gentle flame, and will be found to be fit for further use.

Civil and Mechanical Engineering.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 321.)

The following from *Overman's Mechanics*, 1851, we reproduce here:

"For the transmission of rotary motion, belts are generally used; iron chains have also been employed, but they are now almost universally abandoned for wire ropes. If an india-rubber, leather, or any other description of belt, passes around a pulley it adheres to to it with a certain force, which may be called adhesion. A certain tension of belts is always required to prevent slippage; besides which, the angle of contact is an element of adhesion. The formula for the force F, which is to be transmitted by a belt of the tension t, is:

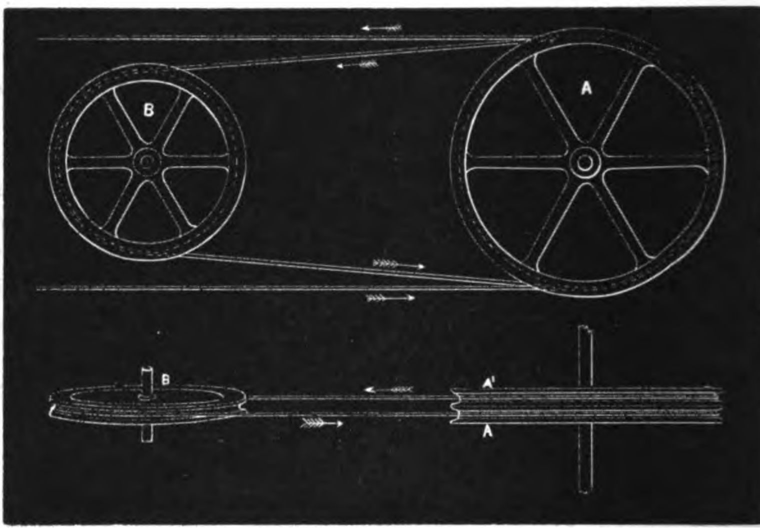
$$\log. F = \log. t + \cdot 434 \times c \times \frac{S}{R}$$

in which C is the co-efficient of friction, log. the common logarithm; S is the arc of the pulley covered by the belt, and R the radius. The common co-efficient of friction cannot be applied in this case; it is ·47 for greased leather upon wood, ·50 for dry leather upon wood, ·28 for dry leather upon cast iron, ·38 for oiled leather upon cast iron, and ·50 for new hempen ropes upon wood. India rubber belts may be classed with oiled leather. To increase the arc on the driving pulley, that which is driven may be made smaller, and to increase the arc on both the belt may be crossed. In many instances, the arc as well as the tension is increased by a tension pulley.

In cases where all these are insufficient to produce the adhesion required, the rope may be put around the pulley more than once, to afford it a longer time of contact. This is particularly resorted to where ropes are to pull heavy loads, as up inclined planes. This arrangement is here represented:

If the pulley A is grooved, of which at least two are fastened to the same shaft, the rope is directed on one of these pulleys, and

passing around it, goes to B, which revolves on an inclined axis, such that the rope will be received from A′ and delivered to A in the plane of the grooves. The number of pulleys may be multiplied to gain adhesion. This method of augmenting friction is preferable to the tension roller, as no increase of tension is required; and it has the additional advantage of bending the rope in the same direction, which makes it more durable.



To determine the strength and size of a belt, find first the amount of labor to be performed by it. This labor is its tension with velocity.

If a belt passes over a 3-feet pulley which makes 100 revolutions per minute, its velocity will be:

$$100 \times 3 \times 3{\cdot}1416 = 942{\cdot}48 \text{ feet per minute.}$$

If this belt is to transmit 2 horse-power, its tension on the pulling side is: $\dfrac{2 \times 33000}{942{\cdot}48} = 70$ lbs.

In this case, it is assumed that one side of the belt is slack; if this is not the case, which in the average of practical instances may be depended upon, the tension on the following side of the belt is subtracted from the above. We here see of how much more service the horizontal belt is than the vertical, for it increases the tension by its own weight, and also the arc of contact. In most of

these cases we may neglect the width of the pulley in the calculation of friction; for the strength of the belt, if sufficient to resist the tension, makes the belt wide enough for adhesion. In all cases it is advisable to make the belt sufficiently wide; no other loss arises from too wide a belt than that of first cost and the loss in rigidity. If a belt is too narrow, or the arc of contact too short, the tension must be increased, in order to afford sufficient adhesion to the pulleys. This tension bears upon both journals of the shafts, and increases the friction twice with the increase of tension. If a tension-roller is applied, the friction is increased still more, partly because the number of journals is increased, and partly on account of the rigidity of the belt, this being bent upon the tension-roller in an opposite direction to that of the pulleys.

A superior material for oiling belts is a solution of India rubber in common linseed oil, which may be rubbed into the belt in the course of its operation, making it soft, adhesive, stronger and more durable than common leather.

Short belts are very disadvantageous, and so are vertical ones; they always require more tension than either long or horizontal belts. Those which are too narrow will stretch, in consequence of which, tension and adhesion are diminished. The adhesion of leather upon iron and smooth surfaces is greater than upon wooden and rough surfaces, for these reasons pulleys ought to be made of iron, and perfectly round and smooth. Frequently we see the surface of the pulleys convex, in order to prevent the running off of the belt: this convexity must be very small, or it will diminish adhesion. The most perfect is the cylindrical form of pulleys for flat belts.

Round ropes, or strings, are conducted by grooved pulleys, in which the adhesion of the rope is increased by the wedge-form of the groove into which it is squeezed; the adhesion of these ropes to the pulleys increases, therefore, as the angle of the groove diminishes.

Round grooves are disadvantageous, because they are destructive to the rope, caused by its sliding on the sides of the groove. The best form for the groove is angular, so that the rope touches but in two places tangential to its circumference."

Telodynamic Transmission.—" There are, at Moulin's Galant, near Corbeil, 22 miles south of Paris, some important paper mills, belonging to MM. Darblay and Company. One of these mills is

worked by an hydraulic wheel of about 30 horse-power. But the power of this wheel not being sufficient all the year round, it was necessary to provide a supplementary power, which has been obtained from another fall on the same river, 770 yards up the valley. This fall, of about 40 or 45 horse-power, was formerly, and is even now, used for working a flour mill, which has been taken on lease by M. Darblay. The connection between the flour mill and the paper mill has been made with a telodynamic wire. This system of transmission consists of an iron endless wire supported by pulleys, and running at a very great speed. It is thus possible to transmit a large power through a very thin wire, and this system is now extensively used in France, especially in the eastern districts. The Moulin's Galant wire is worth notice, because, besides its great length, the axles of the driving and driven pulleys are neither parallel nor situated at the same level. The angle between these axles is 8° 10′, and the driving axle is 14 feet 1 inch above the other; both are, of course, horizontal. The wire has been arranged in a polygonal line, and at each summit of this polygonal line there are two pulleys, bearing the driving and the driven wire. It was necessary to give to the axles of these pulleys such an inclination that the plan of the pulley should include the tangents of the two adjoining curves of the wire by each side of the pulley. The shape of these curves and the inclination of their tangent had accordingly to be calculated with the greatest care; and the pulleys had afterwards to be accurately arranged in the calculated situation. Any mistake in these calculations would produce a great waste of power, and sometimes would enable the wire to get out of the grooves of the pulleys. All this plant has been successfully arranged by MM. Callon and Vigreux, civil engineers, and it has worked quite well for nearly eight months. The diameter of the rope is $\frac{1}{2}$-inch, it weighs 9 pounds per yard, and it consists of 48 iron wires $\frac{1}{24}$-inch diameter, and of a central hemp strand of about $\frac{1}{4}$-inch diameter. The speed of the rope is 61 feet 9 inches per minute, and the calculated strain is 666 pounds on the driving and 313 pounds on the driven wire. The diameter of the driving and driven pulleys is 8 feet, and they have an angular speed of 150 revolutions per minute.

The hydraulic wheel running only $3\frac{1}{2}$ revolutions per minute, the proper speed is given to the driving pulley through two intermediate wrought iron shafts, supplied with cast iron spur wheels. The

wire is supported by seven intermediate pulleys, 6 feet 6 inches in diameter, and there is an average span of 246 feet between these pulleys.

There are some masonry piers, 10 to 20 feet high, carrying these pulleys, and supplied with wrought iron ladders for oiling the journals.

The average deflection of the wire between the pulleys is 10 feet for the driven and 5 feet for the driving wire. This latter runs very near the ground, in some places through the meadows. The inclination on the horizontal of the shafts of the pulleys is 4° 8′ for the driven, and 8° 28′ for the driving wire. It is also necessary to calculate very accurately the total length of the rope; upon the length depends the tension; with a too great length the wire would be allowed to slip in spite of the leather lining of the grooves of the pulleys; with too short a wire the friction would be uselessly increased; in both cases the wire would be liable to fall down the pulleys. This dangerous accident happened once at Moulin's Galant, the wire being pulled by a hay cart crossing under it, but nobody was injured.

The calculated slack of the wire is about 20 feet, and this length has been ascertained to answer quite well. There is a telegraphic connection between the two mills, in order to stop the wheel when there is some accident to the paper mill. The flour mill is of course kept at work when there is in the river a sufficient flow of water, and when all the requirements of the paper mill are performed. The waste of power by friction is about one-sixth of the total power, The wire is without any connection with the paper engine of the paper mill, which is worked by a small steam engine.

It must be remembered that when such ropes are worked in connection with a steam engine, this latter wants a very powerful quickly acting governor, in order to prevent the overruning of the engine, should the wire suddenly break down. Such an accident happened some years ago in a cotton-spinning works in Alsace, and a large steam engine was entirely destroyed."— *Cor. The Engineer.*

(To be continued.)

ENGINEERING OF THE PERIOD.

By William M. Henderson, H. E.

To the thinking engineer, whose province it is to master the really valuable in the experience of his predecessors, to prepare his mind for future improvement, the present time, fraught with so many inventive absurdities, is deeply instructive.

In the course of this review, we may find profit in subjecting to examination a few of the most notable of recent innovations. Before entering upon the task, however, it will be quite apropos to draw attention to the great cause of this retrograde movement in the development of mechanical science in the United States. There is no other country where barefaced deceptions could be so continuously and successfully exercised as in this. Such outrageous absurdities as are here daily palmed off upon a patient people would never be tolerated in any other, for the simple reason that the study of engineering is not made so professional as is the case in Europe. Without exaggerating the case in the slightest, a man here may be a shoemaker one day, an engineer the next, and an editor of some mechanical publication on the third. The writer is personally acquainted with several cases in point. That our mechanical journals, with but a few honorable exceptions, are mere compilations of trash, is a fact well known to the intelligent engineers of the country—periodicals gotten up as advertising mediums of patent agents and solicitors, periodicals not to be read with the hope of ever being benefitted thereby. By the same process of instantly creating engineers, men profoundly ignorant of the science of mechanics succeed in bolstering themselves up in high places, having the gift of awarding large contracts for machinery they know nothing about. That such men can be prevailed upon to yield to the importunities of plausible inventors and their abettors, is a part of our national history and disgrace, ramifying throughout all branches of industry, from the construction of a man-of-war to that of the broom used by the scavenger of the street. The remedy for this is very apparent. Questions of mechanical necessity, national, municipal or domestic, should be alone decided by a committee of properly qualified experts, as a convocation of learned doctors is summoned to consult upon cases of great moment. Then,

and only then, may we expect to compete favorably with other nations, and patient merit will meet its just reward.

First in the category of exploded inventions, we will briefly revert to the attempted revival of Newcomen's atmospheric engine of 1705, by the late Thomas Eubank, of New York. His description of this scheme will be found at length in the *American Artizan*, June, 1866. We will merely notice one or two of the most important paragraphs, and pass on to other designs, now before the public. Mr. Eubank declared: 1st. In all cases there remains *as much* power in the discharge steam (from a steam engine) as imparted to the piston, however great that may have been;" and, 2d. In most cases, *more power*, and in some cases *double the power* may be obtained from it. He argues that with a separate condenser the judgment that consigned Newcomen's engine to disuetude will have to be reversed, and dwells upon the inference to be hereafter drawn from our employing the force that expands a volume of water into 1700 volumes of vapor, and neglecting that which is evolved by the shrinking back of the 1700 into one. The mode proposed to utilize the whole force consists principally in adding an atmospheric cylinder to the steam cylinder, as much larger than the latter, as the tension of the steam used is above atmospheric pressure. Such an engine would never approach in economical results that which is already being done by the condensing engines of the present time, using high pressure steam, with an early cut-off, expansion being carried to atmospheric pressure and final condensation. We already gain all the benefits to be derived from the source pointed out by Mr. Eubank, and a great deal more from the introduction of the principle of expansion, which he seems totally to have forgotten. This engine, we believe, never assumed any definite shape, although it would be vastly suporior to others which are at this time forced upon our notice. Perhaps the most noticeable of these is one that is now on exhibition in Philadelphia, and which is causing no little commotion amongst farmers and others, a description of mechanical band-box.

This remarkable specimen of steam motor is of exceedingly antiquated origin, being the original creation of one who flourished about 120 years before the Christian era. It has been known to the world for the past 2000 years as the Æolopile of Hero of Alexandria, being the first capital step in the invention of the steam

engine. It will be needless here to offer any description of this interesting relic.

Passing on through the lapse of time, the second candidate for mechanical renown, in connection with the history of the steam engine, was an Italian philosopher named Brancas, who invented the float wheel, about the year A. D. 1629. The description shows this to be similar to the wheel now adopted for water power, having buckets arranged around the periphery, a jet of steam being projected against the floats caused rotation upon the axis. The wheel is described as being used horizontally or vertically.

We will now take this Æolopile of Hero and envelope it with the float wheel of Brancas, supply steam to the hollow arms of the former, and let the issuing jets impinge upon the floats of the latter, and we have the remarkable steam sieve alluded to, which, we are assured, will effect a saving of fuel amounting to 25 per cent. greater than can be produced by the very best cut-off engines. It will be seen from this description that the two shafts revolve in opposite directions. Motion is communicated by pullies from each to a single shaft, one of the belts being crossed, to cause this shaft to revolve continuously. It might be asked in connection with this, what is possibly gained by dividing the work, and what would be the difference if either abutment was stationary, and the whole force of the steam directed thereat, as was the practice of the ancients, instead of one part yielding and absorbing half the force, with no other purpose than to create friction and lessen the developed power.

(To be continued.)

Curious Effects Produced by Lightning.—Dr. J. G. Fischer, in *Pogg. Ann.*, No. 8, 1870, describes at length some singular effects caused by the lightning striking his house, a detached building situated some distance from Hamburg, on the 17th June last. The lightning first struck and demolished a stack of chimneys, and next found its way to the soil along a zinc pipe, used for conveying the rain water from the roof downwards. The pipe alluded to, though previously sound, was perforated in three places in a very curious manner. At one of the holes, the metal was forced outwards, while at the other two the metal had been forced inwards in such a manner as to close the tube for the passage of water, at the point where the tube reached the earthenware drain-pipe; the latter was smashed, the soil which covered it having been scooped out. No fire ensued by the striking of the lightning, nor was fusion of metal anywhere perceptible. None of the parties present in the house at the time of the occurrence, were at all injured.

THE ALLEN ENGINE.

By CHARLES T. PORTER.

(Continued from page 325.)

Construction.—It has been attempted to make the details of this engine worthy of its principles, and it is believed that in this respect also it exhibits an improvement on existing types corresponding with that presented in its valve and crank action. Strength, truth, extent and durability of wearing surfaces, and simplicity have been the objects especially sought.

A few of the more important features will be briefly noticed.

The bed is massive, and is in its form well suited to maintain perfect rigidity, whatever power the engine may be exerting. The cylinder is secured to the bed in a manner insuring truth of position, and bringing the centre-line near to its surface. The support of the cylinder is at once firm and adjustable, and leaves it free to move by expansion and contraction. The cylinder and the steam and exhaust chests are combined in one casting, but a belt is interposed to protect the cylinder from the cooling blast of the exhaust vapor. The heads are hollow, preventing external cooling, and the steam is taken directly into the cylinder, without being first cooled and condensed in a jacket.*

There is no small piece which can become loose in the cylinder. The piston is a solid mass, of a depth equal to one-half its diameter, as shown in Figure 1, Plate I, and combines the desired weight with absolute simplicity. It may be objected that the weight of this piston will wear the cylinder. This objection will vanish, however, when it is considered that this is only from two pounds to four pounds on the square inch of cylinder, being least in the smallest cylinders, that it is evenly distributed, and runs on the bottom, where it is well lubricated, and that ordinary packing-rings, and the pistons of large marine horizontal engines, both exert a pressure many fold greater.

It is certain that steam cannot get inside of this piston. It is packed with small cast iron rings, turned larger than the cylinder,

* There is, however, no doubt that a steam-jacket which does not communicate with the ports, and is supplied with steam of a higher temperature than that worked in the cylinder, and which has a free drainage back into its own boiler, is economical and advantageous, when it is practicable to employ it.

bored slightly eccentric, cut as shown on their thin side, and sprung into grooves. These answer admirably, and are very durable. Wrought iron rings are worthless. The whole can easily be pushed through a 16-inch cylinder by hand.

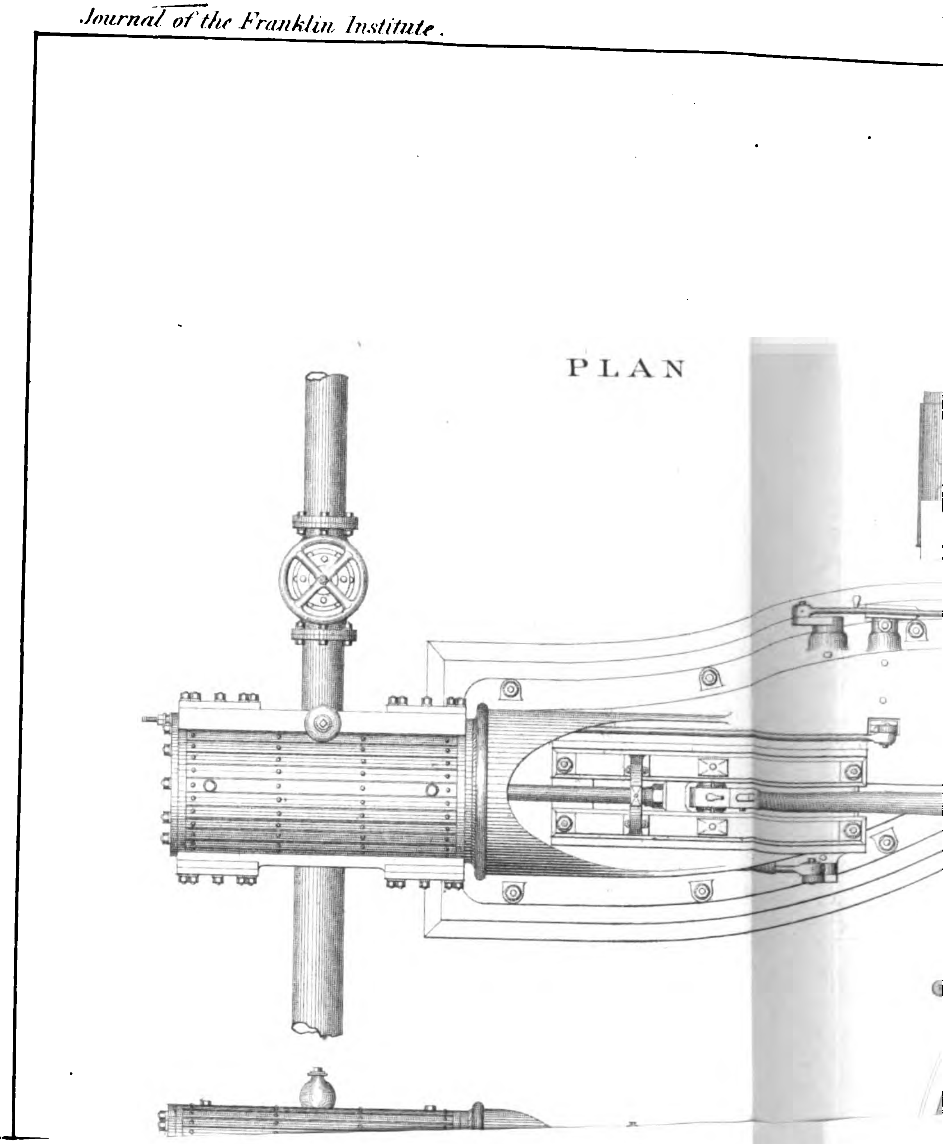
The piston is secured on the rod by shrinking. The plain parallel rod is merely held in a parallel hole. The subject of shrinking is so little understood that it is commonly supposed a piston cannot be held on the rod without a nut or a key—means of fastening so trivial in the comparison as to be ridiculous. It must be confessed that ordinary turning, and more especially boring, can not be relied on for this purpose, which requires work of a superior character. In these Works, the rod for shrinking is made larger than the hole by ·0025 of an inch for each inch of diameter, and they are held with such force that they will part before they can be drawn out. Their tightness is tested by sound. The rod, when lightly struck, must give out a clear, musical and sustained tone.

The cross-head is of cast iron, running on cast iron guides. No other combination of metals is so durable, if the surfaces do not become injured. This is abundantly guarded against in these engines by the extent of surface in the cross-heads, equal to four-fifths of the area of the piston, and by the equal distribution of pressure over this surface. This latter is ensured by making the surfaces of the cross-heads and the guides true planes, and the cross-head itself a simple solid block of considerable thickness, and by jointing the connecting-rod in the centre of it.

The crank and cross-head pins are made about twice the usual size; the latter is made separate, and is set in the cross-head in the manner shown in Figures 1 and 2, Plate I, and the surfaces of both are hardened and ground.

The connecting-rod is made six cranks in length. The crank-pin boxes are secured in the solid rod end, and wear is taken up by a wedge, as shown in Figure 5, Plate I. This is an admirable arrangement. The length of the connecting-rod remains nearly permanent, varying only by the difference, if any, between the wear of the two pairs of boxes, instead of being, as is commonly the case, shortened by the sum of their wear.

The shaft is large, and its journals are long and large, as are all joint-pins, by grinding between dead-centres with a traversing wheel, to produce a true cylindrical form. Aside from the diminished wear, and the safety against warming, which this perfection


PLAN

of form secures, it also materially increases the effective power given off by the engine.

The bearing-blocks and connecting-rod boxes are lined with Babbitt metal, made of copper, tin and antimony.*

These blocks are made very heavy, and without flanges. The defect of the overhanging action of the single crank, often so little regarded, and the source of so much trouble, is, in this engine, reduced to a minimum, by bringing the centre line as near as possible to the bearing, and by employing a short crank and a stiff shaft; but, above all, by the action of the reciprocating parts in preventing violent shocks and strains.

The device will be observed which prevents oil from the bearing working out on the crank-disk.

In all other engines working very expansively, one principal office of the fly-wheel is to resist the violence of the steam at the commencement of the stroke, which it does by excessive torsion of the shaft and strain on the crank; and another is, to maintain the motion as well as possible when the steam in the cylinder has, by expansion, nearly or quite lost its force above the atmosphere.

In this engine, these offices, as has already been explained, are performed by the reciprocating parts, and the force exerted on the crank is, by their action, made nearly uniform. Nevertheless, a fly-wheel is employed quite equal in regulating power to those which have the above duties to perform, and the result is a much closer approximation to uniform motion, under all circumstances, than is possible with any slow-working engine.

Attention is invited to the construction of the outer pillow-block. This is made very substantial, with a broad base, and is set on a base-plate, on which it is adjustable by keys, to enable the shaft to be exactly lined, and readily readjusted, if from any cause it gets out of line.

(To be continued.)

* This was a composition, the virtue of which was better known to the past generation, it having latterly given place to one of lead and spelter.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 310.)

Planing Machinery.—In an old English patent relating to planing machinery, there is a clause in the specification quaintly headed, "Presentment and Adjustment." Although the terms sound strangely enough to our modern ears, they comprehend the most important principle involved in the operation. To design and apply cutting edges with motions adapted to the work is a less task than to "steady and present" the material to be worked upon. In wood-working, as well as in metal-working machines, and engineering tools generally, if the cutting or displacing agencies were separated from those that present and steady the material, the latter would comprehend the largest share of ingenuity as well as constitute the most important elements of the machines. The proposition that all machines, or at least all engineering tools, comprehend these two elements, and the study of the relation between them, has been one of the recent innovations in the engineering arts. Whether in cutting and shaping large masses it is better to move the tool, or the piece, as it is familiarly called in the shop, is the question.

Messrs. Wm. Sellers & Co. have considered this question in its relation to machines for planing metal, and have, no doubt, with their well-known engineering skill determined a practical basis, for the relation between the "tool and the piece" in such machines.

Their machine, exhibited at Paris in 1867 for heavy planing excited much comment, and although a symmetrical and effective machine for heavy work, the idea of moving tools has not been carried out in their smaller machines, which warrants the conclusion that for planing light pieces, the machines are simpler and more effective with a movable table or carriage.

The Industrial Works, W. B. Bement and Son, have designed and put in operation in their establishment a massive machine with moving tools to cut material that is mounted on a stationary bed. The idea was, however, to meet the special requirements of their establishment rather than general purposes, so that its performance and adaptation will furnish but few data bearing upon the general question of moving tools and moving material.

This notice of metal-working machines is made upon the assump-

tion that the general conditions of cutting and shaping material are much the same, and the question of relative movement in tools and material must, in wood as well as metal-cutting machines, be considered.

As stated at the outset of these articles, the metal-working machines having absorbed nearly all the scientific attention thus far, it is no more than fair to "halve the matter amicably," and contribute a share of the experience gained in this direction, to their neglected adjuncts, wood machines.

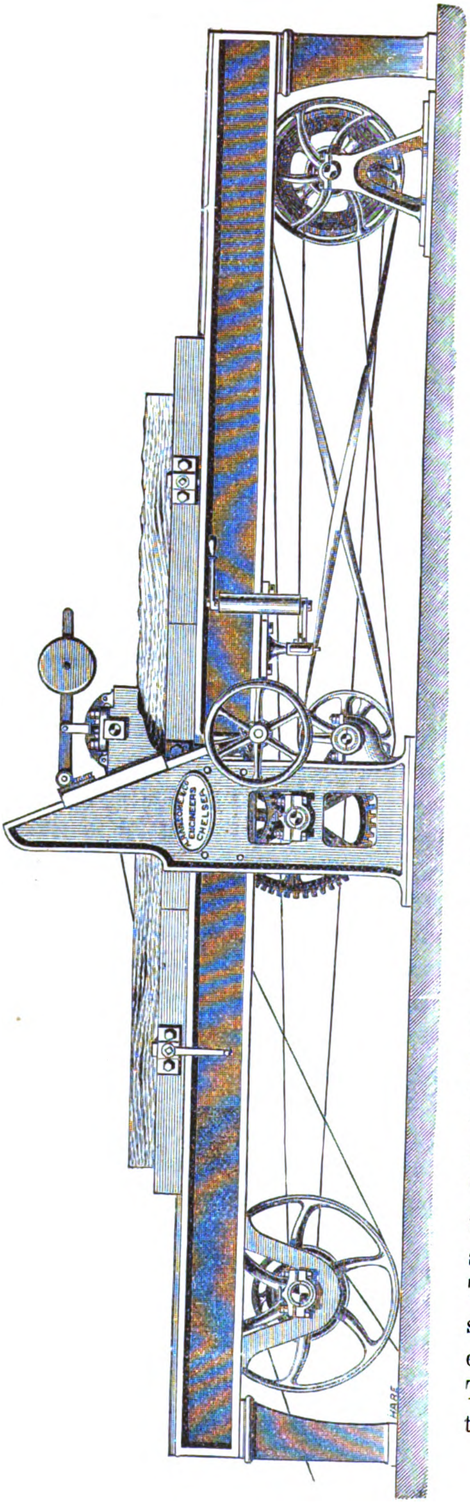
A German patent on wood planing machines, the invention of Theodore A. Prale, of Hamburg, was, in 1864, issued in England for a transverse wood planer with movable tools, and a stationary bed (No. 2110, 1864). Six years having now elapsed and no mention of the practical working of these machines coming to us, it is safe to infer that those terrible impediments, "practical difficulties," have defeated them. It is possible that bad engineering may, with the monopoly of a patent have prevented its introduction, but still, when we form an "account" with what is gained against what is lost, the balance will no doubt appear on the side of the popular machine with the moving bed.

The chief distinction between machines for longitudinal planing, constructed on the two plans is in the length of the framing and guides.

With a movable bed the material must be traversed *twice its length*, while in moving tools the same length of "cut" is obtained with half as much travel or stroke; or, as it might be more properly stated, the length of the material must be added to stroke so far as the track and main framing is concerned. In wood-cutting where the weight of the material is not, as in metal work, to be taken into consideration, there seems to be nothing beyond this single feature gained with the moving head, while there is endless complication introduced in the feeding and driving mechanism of the machine. It is to be regretted that any drawing of the German machine to a scale sufficiently large to render it intelligible, would be beyond the limits of the *Journal*, or otherwise an engraving would have been prepared.

Having now "generalized," as far as the matter can have any interest, we will return to the subject where it was dropped in the last number.

An ingenious type of the transverse planer with a horizontal spindle and feeding rolls, generally known as the Baker Planer,



was extensively introduced throughout the U. S., some eight or ten years since. It had a wide range in its adaptation and filled many useful places for dressing small framing and bent work, having arrangements for feeding curved as well as straight pieces.

It bid fair for a long time to become a standard machine, and should have become so, had it not been for that unfortunate faculty, possessed by so many of our American wood machines, of falling to pieces just when it had the most to do. A machine built on this plan with good substantial proportions and well "fitted up," would no doubt find a permanent place in most of our large shops.

We have the pleasure of presenting in this number, (Fig. 1,) an excellent engraving of a dimension planing machine with a horizontal cylinder from the designs of the manufacturers, Messrs. A. Ransome & Co., of London, England. These machines are built of two sizes, weighing, respectively, 2 and 3 tons. The engraving is of the smaller machine, a true elevation ½ inch to 1 foot. The tables are from 10 to to 16 feet long, cast in one

piece, running on V tracks in the manner of metal planing machines; the tracks are "scraped in," and every part of the machine so fitted that the surfaces produced are ready for gluing, or finishing with sand paper.

The table is fitted with cramp jaws, operated by crank screws, at intervals of 4 feet for holding the lumber.

Clamping the stuff "sidewise," or across its section for short stuff, forms an admirable means of fastening, but for long or flexible stuff has some objections. Taking, however, the general character of the work that these machines have to do in England and in their market, it is no doubt as good a device for holding and "presenting" the stuff as can be devised.

The dimension planing machines with the axis of the cutting cylinder transverse to the line of the material constitute a different class of machines from those heretofore designated "transverse planes," being a combination of the dimension planer and the roller feed machines for "thicknessing" stuff.

They can be used with great advantage in dressing any kind of stuff that is stiff enough in its cross-section to stand the action of the cutters without springing.

Their advantage consists first in the amount of cutting edge that can be applied, and the consequent speed of the work, and secondly, in the smoother surface that is left by the cutters acting parallel to the fibre. With a well made machine and lumber that is stiff enough to resist the cut, these machines produce the smoothest surfaces that can be made with rotary cutters, except with the Whitney Scraping Planer which will be noticed in its order.

In dressing the framing of agricultural implements, and for other work of a similar character, these machines will dress framing smooth enough to receive the paint without subsequent hand-smoothing, making a very important saving over its more accurate rival, the Daniels or transverse planer.

The mechanism of these machines, aside from the cutting cylinder being the same as in the transverse machine and all the conditions of its operation being about alike, there would be no interest in reverting to the feeding and reversing gearing.

Machines of this kind with an extra attachment for roller surfacing are extensively built by a firm in Boston, Mass. The framing and table being mainly of wood. "Convertible" machines, like "Universal" machines, are, however, a thing of the past in

our American shops; the study being to "segregate" rather than to "aggregate" functions. When our manufacturing interests were small and undeveloped, and when machines were regarded as an adjunct or auxilliary to hand labor, then a combined machine, capable of doing several kinds of work, had a place to fill in our small shops; but that day is gone, and, as before assumed, it is much better to exercise our ingenuity in separating instead of combining functions in the same machine.

It would, however, be safe to except a single machine in our large shops that would be able to do the "jobbing" without interfering with the standard machines or breaking the system of the shop—a machine that will saw, mould or rebate, &c., with the attention of one hand economizes room and expense for jobbing, but on regular manufacturing, the less combination the better.

A friend of the writer some years since devised a machine that performed all the operations needed to complete a carriage wheel, exhibiting great ingenuity and perfect performance, but he was astounded to be told by an extensive manufacturer, who set up his machine, for experiment, that he would require *fifty* machines to do his work, and advised him to "separate it," in other words, to undo what he had done, and leave the machine where he had found it. In eight or ten parts, each one doing its allotted work, without intermission and requiring the attention of an operator, who, like the machine, had his attention fixed on some special branch of the work, his machine would have given a different result.

Compounding functions has, in thousands of instances, and, as we might say, generally, been confounded with useful invention; but the principle, as a rule, leads only to a loss of time and a waste of wealth, the component parts of the machines returning to their original form to meet the requirements of actual practice.

To define the line between invention and combination, between principles and modes of action—or, in other words, to define invention—is a problem that the greatest minds have failed to solve, at least in any comprehensive manner that would furnish a standard from which to judge of every case that arises, and it is not strange that even a good mechanic should mistake combination for useful invention. Combination may, of course, constitute invention, but so far as utility is concerned, some other field than that of wood machinery must be sought to find it. The enormous extent of our factories, the division of labor system—in fact, everything points to a division of work among as many machines as possible.

(To be continued.)

SURVEY OF THE NICARAGUA ROUTE FOR A SHIP CANAL.

By Col. O. W. Childs, C. E.

(Continued from page 330.)

For statement in tabular form of the length of the levels, lockage, and the distances, fall, &c., of the San Juan River, see tables C and D, appended to Mr. Fay's report.

Supply of Water.—The quantity of water required for the canal consists in that to be used for lockage, and in the amount lost by leakage at the locks and dams, and filtration and evaporation from the prism of the canal.

In estimating the quantity necessary for lockage at both ends of the summit level, it is assumed that three locks full may be required per hour at each lock, amounting to .... 12,000 cubic feet per minute.

Taking the leakage of an 8 feet lift lock of the original size on the Erie Canal at 900 cubic feet per minute, which is the largest known to have occurred, and increasing this quantity in proportion to the increased surface pressed by the water, (excluding the side walls,) and it gives for the quantity required to supply the loss by leakage at the two summit locks .... 16,682 cubic feet per minute.

The loss by filtration and evaporation during the hottest months of the season, or period of the greatest drought on the original Erie Canal as ascertained from the most authentic data, is 85 cubic feet per mile per minute; increasing this quantity in proportion to the square root of the depth of water, and the area of its surface in contact with the earth, shows the amount required per mile per minute to be 433·30 cubic feet; this multiplied into 11·23 miles, the sum of the distances in both directions to be supplied from the summit, and it gives for the whole quantity required to supply loss by filtration and evaporation .... 4,868 cubic feet per minute.

To this add 10 per cent. of the minimum flow of the San Juan River, the amount estimated to be required to supply the loss by leakage at the dams equals 71,580

cubic feet per minute, and we have .... 105,130 cubic feet per minute, as the quantity to be drawn from the lake during the dryest portions of the seasons to sustain the navigation, and give full employ to the locks.

Rain.—The fall of rain from September 9th, 1850, to September 25th, 1851, a period of twelve months and seventeen days, was carefully ascertained by means of an ombrometer or rain guage. The observations were in all cases taken by a member of the party, except during a term of thirty-four days in September and October,

1850, when they were taken by Don Fruita Chomorro, then Prefect of that department of the State, a gentleman of high scientific attainments, whose accuracy in the performance of this voluntary service, is entitled to the fullest confidence.

The observations were taken at Rivas de Nicaragua, from September 9th, 1850, to March 11th, 1851, and from the latter period to September 25th of the same year, they were taken on the San Juan River.

The following are the results of the daily observations:

STATEMENT *of the Rain in the State of Nicaragua from September 9th,* 1850, *to September 25th,* 1851, *showing the amount in inches and decimals of an inch, for each day in each month in which rain fell; the aggregate for each month, and the total during the above period.*

Date of Month.	Sept., 1850.	Oct., 1850.	Nov., 1850.	Dec., 1850.	Jan., 1851.	Feb. 1851.	Mar., 1851.	April, 1851.	May, 1851.	June, 1851.	July, 1851.	Aug., 1851.	Sept., 1851.
1	......	......	......	......	......	......	......	......	......	......	110	030	......
2	......	130	......	......	......	......	......	......	......	......	020	090	2·710
3	......	2·720	......	......	......	......	......	......	......	......	......	......	4·710
4	......	030	......	......	190	......	......	......	......	460	......	960	......
5	......	290	240	......	......	......	......	......	......	920	660	1·320	640
6	......	210	......	......	......	......	......	......	......	......	1·950	770	......
7	......	......	310	600	......	......	......	......	......	350	490	......	160
8	......	......	......	1·270	......	......	......	......	......	......	720	......	......
9	......	......	......	010	......	......	......	250	......	730	700	1·260	300
10	010	......	......	......	......	......	......	......	......	660	......	1·510	......
11	......	......	......	270	......	......	......	......	660	060	1·230	540	......
12	440	1·300	020	......	......	......	......	......	660	240	2·650	630	1·110
13	060	090	......	......	......	......	......	......	......	......	270	040	......
14	750	1·900	......	490	......	......	......	......	130	1·380	070	......	......
15	......	2·230	......	......	......	......	......	......	......	1·820	220	490	......
16	260	2·790	......	......	......	......	......	......	040	160	580	640	......
17	260	290	......	......	......	......	......	......	840	......	780	......	......
18	310	1·150	......	350	......	......	......	......	140	......	......	050	470
19	1·030	040	180	......	......	......	......	......	......	350	190	......	1·720
20	090	140	......	......	......	......	......	......	920	......	520	530	......
21	930	010	......	......	190	......	120	......	270	990	......	......	......
22	290	......	......	......	......	......	......	......	3·030	......	1·340	240	270
23	190	......	......	......	......	......	......	......	120	710	......	......	080
24	......	1·740	......	......	......	......	550	......	......	......	......	1·010	......
25	......	......	......	080	......	......	......	......	......	090	450	......	070
26	......	2·040	......	140	......	......	......	......	760	100	5·920	500	......
27	230	......	045	......	......	......	470	......	425	830	410	610	......
28	170	......	......	......	......	......	......	......	500	2,770	......	090	......
29	1·600	070	600	......	......	......	......	......	130	300	520	500	......
30	385	690	......	......	......	......	......	180	270	1-390	2·290	......	......
31	......	......	......	......	......	......	......	......	250	......	510	......	......
	7.005	17·860	1·395	3.210	380	......	1·410	430	9·145	14·210	22·640	11·810	13·240

Total.................... 101·735 inches.

The following condensed statement shows the monthly fall of rain in the State of Nicaragua, embracing a period of one year, from September 9th, 1850, to September 8th, 1851, inclusive:

Months.	Times between which it rained. From	Times between which it rained. To	No. of days in which rain fell.	No. of days in which no rain fell.	Amount of fall in inches.
1850—September	9	30	16	14	7·00½
October	2	30	19	12	17·86
November	5	30	6	24	1·39½
December	7	26	8	24	3·21
1851—January	4	21	2	29	38
February	1	28	0	28	0·00
March	21	24	3	28	1·41
April	9	18	2	28	43
May	11	31	16	15	9·14½
June	4	30	19	11	14·21
July	1	31	23	8	22·64
August	1	29	20	11	11·81
September	2	8	5	4	8 22
Total for the year	....	....	139	226	97·71½

From the above, it appears that in a period of one year the whole number of days in which rain fell was 139, and the whole number of dry days was 226; that during the six months from May to October, inclusive, the period distinguished as the wet season, the whole fall was 90·89 inches, and during the remaining six months, distinguished as the dry season, the fall was 6·82½ inches; the greatest fall in any one month was 22·64 inches, in July, and that there was one month only, February, in which no rain fell. It would have been interesting as affecting the daily progress of work on the canal, to have made a distinction in the amount of fall in time of day and night; this not having been done it can only be observed that the largest proportion of the fall is supposed to have occurred in the night. The fall is almost invariably by showers of short duration, which mostly occur in the latter part of the day and in the night.

(To be continued.)

Mechanics, Physics, and Chemistry.

F. ZÖLLNER; ON THE TEMPERATURE AND PHYSICAL CONSTITUTION OF THE SUN.

[Report of the Royal Saxonian Scientific Association. Mathematical and Physical Class. Session of the 2d of June, 1870.]

(Concluded from page 359.)

According to the supposition, the opening through which the protuberances pass, lies in the liquid incandescent separating stratum at a depth $h = 8''$ under the visible limit of the solar disk. H, in the above formula, meant the height of a protuberance from the plane of the opening.

Let τ = the time required by the protuberance to reach the height, H, *from the opening.*

τ_1 = the time required by the protuberance to reach H from h, the outer limit of the photosphere.

v = the velocity at the opening.

v_1 = the velocity at h.

Assuming the former cause, and neglecting the decrease of gravity (g), we have:

$$\tau = \sqrt{\frac{2\,\mathrm{H}}{g}}, \quad \tau_1 = \sqrt{\frac{2(\mathrm{H} - h)}{g}}.$$

$$v = \sqrt{2\,g\,\mathrm{H}}, \quad v_1 = \sqrt{2\,g\,(\mathrm{H} - h.)}$$

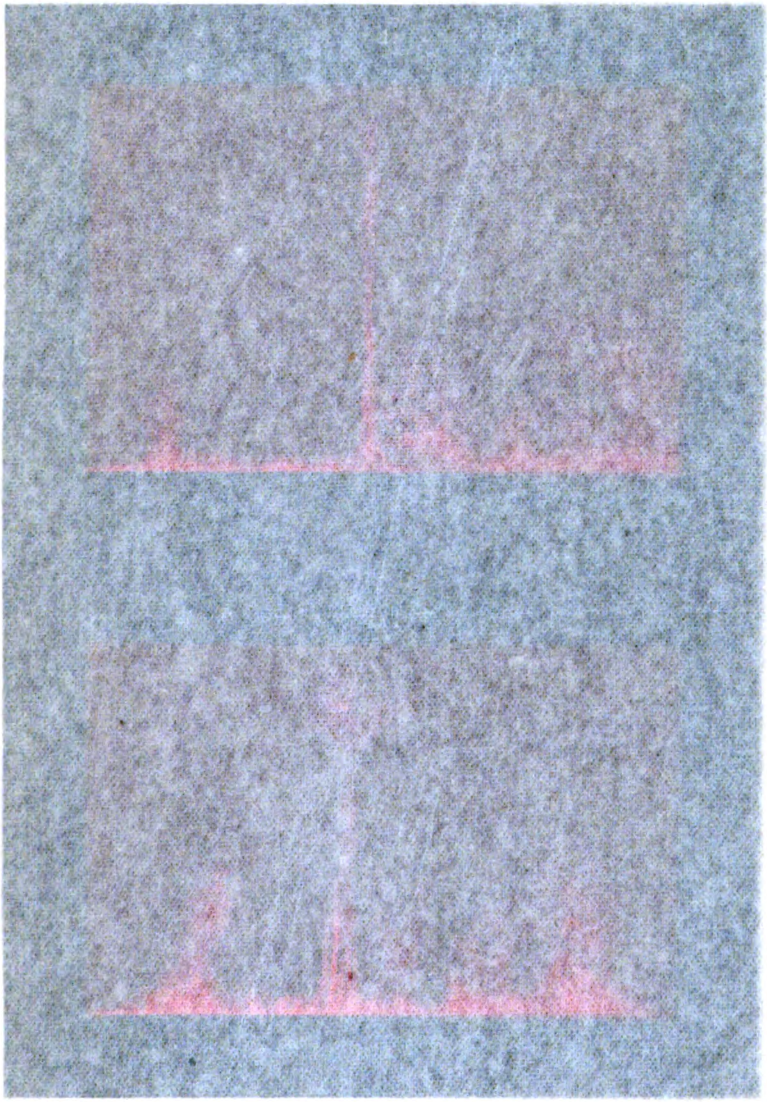
Assigning the following values:

$$\mathrm{H} = 64{,}370{,}000 \text{ m.}$$
$$h = 5{,}722{,}600 \text{ “}$$
$$g = 274{\cdot}3 \text{ “}$$

we have

$$\tau = 11 \text{ min. } 25 \text{ sec.}; \; \tau_1 = 10 \text{ min. } 54 \text{ sec.}$$
$$v = 187{,}900 \text{ m., or } 25{\cdot}32 \text{ geogr. miles.}$$
$$v_1 = 179{,}400 \text{ m.,} = 24{\cdot}17 \quad \text{“} \quad \text{“}$$

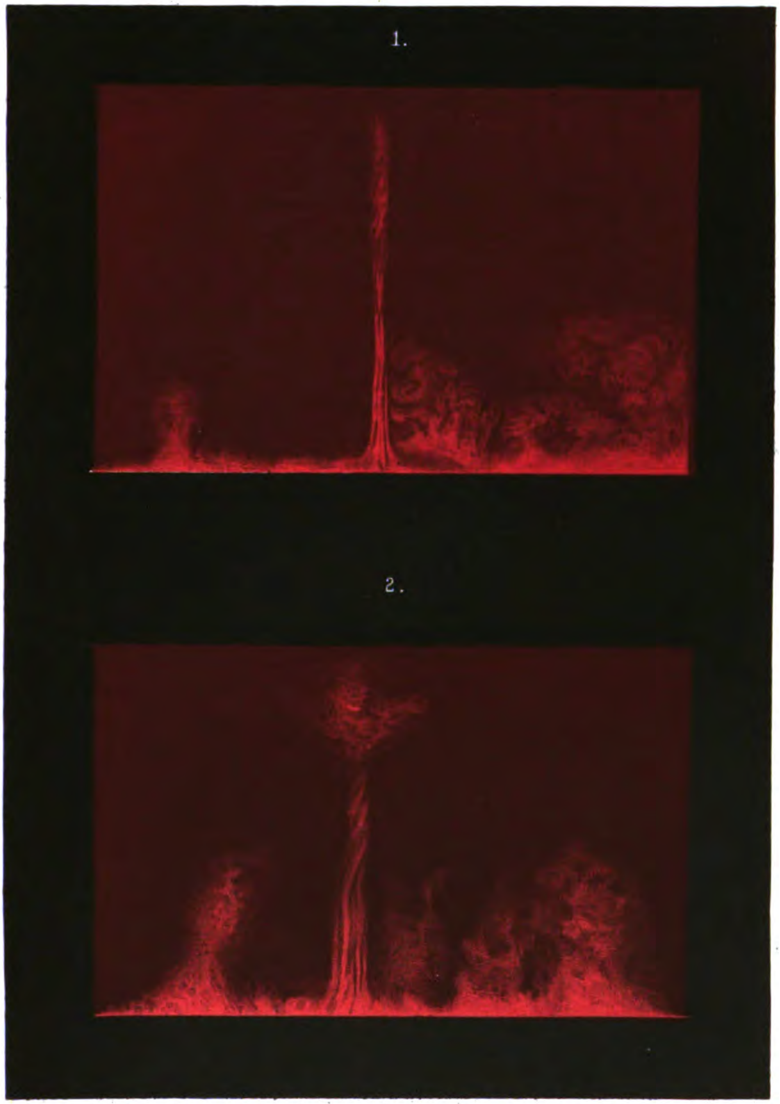
If, therefore, we observe such a velocity in a protuberance, we are justified in substituting the corresponding height in our formulæ. I have observed such a velocity frequently, and take the liberty of placing before you the drawing of a protuberance whose velocity corresponds very well with the above. (Figs. 1 and 2, Plate I.)



... ner del.

0 1 2 3 4 5 6 ... 8 ...

1869, August 29.



F. Zollner del. Longacre & Co., Phila.

Geographical Miles.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15000

1869, August 29.

FIGURE 1.

Position 160°
Time, 10^h^ 22^m^

FIGURE 2.

The same Protuberance
Time, 11^h^ 20^m^

Lockyer's* beautiful observation of the change of the refrangibility of light led him directly to exactly similar magnitudes. He found the maximum velocities of streams of gas moving vertically or horizontally in the chromosphere to be 40 and 120 English miles a second. The above values, reduced to English miles, become

$$v = 123{\cdot}1, \text{ and } v_1 = 117{\cdot}7,$$

and therefore correspond to those of Lockyer.

According to the mechanical theory of heat, such velocities of hydrogen necessitate differences of temperature amounting to 40690° C. We may, therefore, ascertain the temperature itself, if we can assign certain limits to the temperature, t, of the outer atmosphere of hydrogen. It has already explained why this temperature has been assumed as approximating that of the openings through which protuberances pass.

4. A limit for t may be found from formula V.

$$\sigma = \frac{b p_h}{a+t}\left(\frac{a+t}{t}\right)^q e^{bm\frac{rh}{(r+h)t}}$$

In this the density σ of the confined masses of gas is expressed as a function of p_h, h and t. I shall now show that σ cannot exceed a certain value, and that, therefore, t is also limited to a certain value, p_h and h having already been determined.

It has been shown before that the explanation of eruptive protuberances necessitates the existence of a separating stratum between the space *from* which they emanate and the space *into* which they pass. Nothing else would make the differences of pressure possible. In reference to its physical condition, we must furthermore assume that it cannot be gaseous, and must, therefore, be either solid or liquid. The former being improbable, on account of the high temperature, we must conclude that the separating stratum consists of an incandescent liquid.

In reference to the inner masses of hydrogen bounded by that stratum, two suppositions are possible, viz.:†

1. The whole interior of the sun is filled with incandescent hydrogen gas, which would make the sun an immense bubble of hydrogen surrounded by a liquid glowing envelope.

* *Proceed. R. S.*, No. 115 (1869), and Comp. Rend., T. 69, p. 123.

† The phenomenon of the formation of bubbles cannot be adduced as an argument against this, because the conditions are entirely different, since the molecular attraction of the envelope keeps the confined gases in equilibrium, and the gravitation of the particles disappears. In the above case, the very opposite takes place. The molecular attraction is insignificant, compared with the gravity of the mass.

2. The masses of hydrogen, bursting out into protuberances, are local collections in bubble-like caverns, which form in the superficial layers of a liquid glowing mass, and burst through when the presence of the confined gas increases.

Under the first supposition, stable equilibrium could only exist if the specific gravity of the outer layer is less than that of the gas below it. Since the density of a globe of gas whose particles are subject to Newton's and Mariotte's laws increases towards its centre, the specific gravity of the outer bounding layer must necessarily be less than the mean specific gravity of the sun. But if we take the mean specific gravity of the sun as the maximum of liquid outer layer, we would be obliged to assume that all deeper layers, including the gaseous one immediately below, have the same specific gravity.

Then the interior of the sun could not consist of a gas, but of an incompressible fluid. All these properties are clearly a necessary consequence of the supposition that the specific gravity σ of the compressed gases forming the protuberances reaches as its maximum the mean specific gravity of the sun.

In that case, we must suppose, secondly, that the sun consists of an incompressible liquid, near whose surface there are collections of glowing masses of hydrogen, which break through bubble-like caverns as eruptive protuberances under certain differences of pressure.

However small these caverns may be in special cases, the specific gravity of the enclosed gases cannot be greater than that of the surrounding liquid, because, otherwise the compressed gases would sink towards the interior of the sun.

The specific gravity of the sun, according to the latest determinations, is 1·46. If this is substituted for σ, 40690 for a in (Form. V.) and 8″ in metres for h, then, if

$$p_h = 0{\cdot}500 \text{ m.} \qquad t = 29500°$$

and if

$$p_h = 0{\cdot}050 \text{ m.} \qquad t = 26000°$$

mean value, $t = 27700°$.

If equation (5) is differentiated with respect to t, then $\frac{d\sigma}{dt}$ becomes negative, *i. e.*, σ decreases for increasing values of t. Hence it follows that the above values for t are also minima.

From this mean value of t, for the temperature of the solar atmosphere, the value of p_h is found to be 0·180 m. These values are the basis of the following calculations:—

The temperature found is about 8 times higher than that resulting from the combustion of an explosive mixture, (Bunsen "On the Temperature of Carbonic Oxide and Hydrogen Flames," Pog. An., CXXXI., p. 172,) and iron must exist, as a permanent gas, in the solar atmosphere.

With the value $t = 27700°$, the inner temperature in formula (I) becomes $t_i = 68400°$.

If the values of t_i and t are substituted in formula (II) we obtain

$$\frac{p_i}{p_a} = 22{\cdot}1,$$

i. e., the pressure in the interior of the space from which the protuberances emanate is 22·1 times greater than the pressure at the surface of the liquid separating layer. If the value of t is substituted in formula (IV) and h is taken at 6″ as before, $\frac{p_a}{p_h} = 766{,}000$, the relation of the pressure on the liquid surface of the sun to that at the height, h, where the hydrogen spectrum begins to become continuous on account of the pressure.

If, for p_h we substitute the above value of 0·180 metres of mercury, get

$$p_a = 184{,}000 \text{ atmospheres.}$$

and

$$p_i = 4{,}070{,}000 \quad \text{"}$$

If we calculate the depth at which the maximum pressure of p_i would be reached in the liquid solar mass of 1·46 specific gravity in consequence of hydrostatic pressure alone, we will find that it will take place at a depth of 139 geographical miles below the surface, *i. e.*, in a depth of 1·46 seconds of arc, or $\frac{1}{658}$ of the sun's radius.

Even if we neglect to consider the liquid state, and calculate that depth where the atmospheric pressure becomes equal to the internal pressure, p_i, assuming a much greater atmospheric envelope of hydrogen, we will find, even with a temperature of 68,400°, that it will be only 27″ under the visible edge of the solar disk, or about $\frac{1}{36}$ of the apparent solar radius.

This shows how rapidly the pressure must increase towards the interior of the sun, and justifies the assumption, that even at such enormous temperatures permanent gases, as, for instance, hydrogen, can only exist in a liquid glowing state in the interior of the sun.

5. An interesting result is obtained if we calculate the pressure in an atmosphere of nitrogen and oxygen, equal in weight and tem-

perature to the above hydrogen atmosphere, at the height where the hydrogen spectrum becomes continuous. If we suppose the pressure of the three atmospheres of H, O and N, to be equal, (p_a = 184,000 atmospheres, which would correspond to the above value of p_{h},) at a depth of 8″ under the visible edge of the solar disk, *i. e.*, at the level of the supposed separating stratum, when at the calculated temperature of 27,000°, the pressure of each of the three atmospheres on the surface of the *visible* solar disk would be as follows:

$$\text{Hydrogen,} \; p_h = 180 \text{ millimetres.}$$

$$\text{Nitrogen,} \; p_h = 323 \frac{1}{10^{78}} \;\text{"}$$

$$\text{Oxygen,} \; p_h = 124 \frac{1}{10^{88}} \;\text{"}$$

Hence it follows, that under the above suppositions, the quantity of the last two gases must be considered as extremely small, compared with that of hydrogen, in that stratum where the spectrum of hydrogen becomes continuous. This would even be so if we should assume the weight of the two atmospheres as many million times greater, although, according to their specific gravities $\frac{1}{14}$ of the quantity of nitrogen and $\frac{1}{16}$ of oxygen would suffice to make the density of these gases *at the base* equal to that of hydrogen. The mean specific gravity of the sun would have to be taken as the maximum of density at the base of these atmospheres, and we can easily calculate from formula (III) and the known specific weights of oxygen and nitrogen what the weight of these atmospheres would have to be in order to reach that maximum.

The result shows that the weight of the atmosphere of oxygen would only have to be 0·56, and of nitrogen 0·64 that of the hydrogen atmosphere.

If we suppose the *simultaneous* presence of all three gases on the surface of the sun, and neglect for the present the influence of the motion of the atmosphere, the rays emanating from these strata which give a continuous hydrogen spectrum, would pass through so slight a quantity of glowing oxygen and nitrogen that the absorption would be insignificant, and the presence of O and N would not be indicated by dark lines in the spectrum, as is actually the case.

Although the motion of the gases would tend to diminish the above differences, the existence of the chromosphere proves the

slightness of this influence in consequence of the intensity of gravitation and the great height of the stratum in question. (Compare Form. 4.)

In order, however, to explain the absence of lines of two such universally diffused bodies as N and O in the solar spectrum, we must also consider the slight emissive power of permanent gases as compared to that of vaporized solids.

If we consider the emissive power of different gases at the same temperature, and for rays of the same refrangibility, with reference to very small quantities of these gases,* the above experiment of Wüllner, in which the slight quantity of sodium vaporized from the glass of a Geissler's tube emitted more light than hydrogen under 1,000 mm. pressure, furnishes the most beautiful proof of the exceedingly great difference in the emission and (according to Kirchhoff's law of the) absorbing power of different gases at the same temperature. This will answer the objection to the above explanation of the absence of N and O lines, that the solar spectrum contains the lines of bodies, the density of whose vapors is much greater, in consequence of their relation to the atomic weights, than that of oxygen and nitrogen.

From these considerations we obtain either directly or indirectly, by deductions, the explanation of which I reserve for another place, the following conclusions:

1. The absence of lines in the spectrum of a self-luminous star does not prove the absence of the corresponding bodies.

2. The stratum, in which the reversion of the spectrum takes place, is different for every body, and lies the nearer to the centre of a star the greater the density of the vapor and the less the emissive power of the body is.

3. In different stars this stratum, other things being equal, lies the nearer the centre the greater the intensity of gravitation.

4. The distances of the strata of reversion for different bodies from the centre of the star and from each other increase with the temperature.

5. The spectra of different stars contain the more lines, under similar circumstances, the less their temperature and the greater their mass is.

* We assume here the perfect transparency of the gas for the rays emitted by it; an assumption which comes nearer the truth the smaller the compared quantities of gas are.

6. The great difference of intensity in the dark lines of the spectrum of the sun and other fixed stars depends not only on the differences of absorption but also on the different depths at which the reversion of the spectra takes place.

In conclusion, I may be permitted to make a few remarks concerning the application of experiments with rarified gases to the heavenly bodies. Lecoq de Boisbaudran (*Compt. Rend.*, t. 70, p. 1091, 10 Mai, 1870,) has recently stated (with reference to Wüllner's investigations of rariability of spectra by pressure and increase of temperature,) that we should be cautious in applying the results so obtained to the consideration of the solar atmosphere, because the changes of the spectra were due far more to temperature than to pressure. Even supposing that this would be verified by experiment, it would only slightly influence the results in the present dissertation. For, the nature of formula [5], by which the temperature of the atmosphere was obtained, is such that the pressure p_h, at which the spectrum of hydrogen becomes continuous, may be very considerably changed without greatly changing the temperature. We have seen that pressures standing to each other as 1 : 10 would produce values of temperature standing as 1 : 1·15.

Nevertheless, the separation of the influences exercised by pressure and temperature on the spectra of luminous gases must be considered as a problem, whose solution is of the highest importance.

Perhaps we shall be able by application of the well-known law of the heating power of galvanic currents and the law of Gay Lussac so to regulate the pressure of the gas by changing the level of mercury that the increase of pressure produced by the temperature during a stronger discharge is compensated by a diminution of pressure produced previous to the discharge. In this way the pressure would be kept constant, and we would be able to investigate the effect of changes of temperature on the spectrum without knowing the temperature itself. In this we would neglect the loss of heat caused by conduction and radiation during the short space of the discharge, and make the heat developed in the current approximately proportional to the temperature of the glowing gas. If the mass of the gas is known we can calculate the maximum absolute temperature of the glowing gas from the time and temperature of the discharge.

ABSTRACT OF A RESEARCH IN ELECTRO-MAGNETISM.

BY ALFRED M. MAYER, PH.D.

(Professor of Physics in Lehigh University, Pennsylvania.)

Read before the American Association for the Advancement of Science. Troy Meeting, 1870.

AT the recent meeting, at Troy, of the "American Association for the Advancement of Science," I read a paper with the above title, in which I explained a new method of measuring and comparing the electro-magnetic forces of helices, and of different forms of cores introduced into them, and gave the results of many experiments with this new apparatus, which is arranged as follows:

Apparatus for the Comparative Measures of Electro-magnetic Forces.—On a table 10 feet long was drawn a centre line and divided into fractions of an inch. This line was then accurately placed at right angles to the magnetic meridian. Two helices, which I designate as E and W, were placed 8 feet apart with their axes in the same vertical plane as the above line. A surveyor's compass, with a sensitive needle 5·85 inches long was so arranged that the point of suspension of the needle could be moved between the helices in the line of their axes. The same battery current passed through both helices, and in such direction that the N pole of each was facing the needle; by reversing the current, the S poles could be opposed to each other.

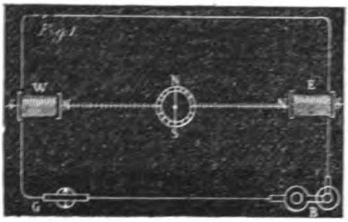
Both helices were composed of 10 layers of ·1 inch "extra covered" copper wire, wrapped on copper spools of 8⅝ inches long, 1·82 inches diameter, and having flanges at the ends 1·25 inches high. These spools, with their flanges, were split in the direction of their length by an opening of $\frac{1}{10}$ inch. Each layer of coils was saturated with a thick solution of shellac in alcohol, and covered with thick paper coated with shellac, before the succeeding layer was wrapped.

Helix E contains 557·5 feet of wire in 696 turns, and on account of its better insulation and greater number of turns, is superior in strength to helix W. Helix W contains 551 feet of wire in 688 turns.

The accompanying diagram shows the arrangement of the apparatus. Helix E to the east of the compass; helix W to the west; at C the compass; and at G the tangent galvanometer, sufficiently re-

moved from E and W not to be affected by the magnetized cores. The Bunsen battery is shown at B.

Fig. 1.



Each end of the compass-needle is thus subjected to the powerful action of two opposing forces, and a magnetic couple is thus formed, whose equilibrium, shown by the needle, is readily disturbed by a change in the relative forces of the cores, or by a change in the distance of the needle relatively to the two helices.

It was found that when the needle was placed at such a position on the line between the helices that it stood at 0° when the circuit was open or closed, and a current passed from 12 cells of a Gaiffe bichromate battery, which was rapidly decreasing in electro-motive force, the needle remained at 0° for over 20 minutes without change or tremble.

Now, if we can find the law which shows the variation of the intensity of action of the electro-magnet on the needle with a change of its distance from the magnetized core, we will have a system of measurement for the electro-magnetic forces which will exceed in accuracy and in delicacy, though be similar in arrangement, to the best photometric processes.

The advantages of this method, as far as my knowledge of it extends, is that you can thus subject the needle to two opposing actions of great intensity, and thus any minute difference in the causes which alter their relative intensities, will, on account of the nearness of the needle to the helices, give a deflection which would be inappreciable in the methods heretofore used; and above all, the same current traversing both helices will, even if inconstant and fitful, affects both proportionately, and the needle, as seen above, will preserve a fixed position at 0° under these circumstances.

From a series of experiments, I found that the law of variation of the intensity of the force of the electro-magnetic cores with a change of distance of the needle from their ends was inversely, as the 2·7404 power of that distance, or as $\frac{1}{d^{2.7404}}$.

The mode of comparing two cores is as follows:—Two cores, found by previous experiment to be equal in magnetization when subjected to the same conditions, are placed in the helices E and W,

and the compass is so placed that its needle remains *at* 0° *when the circuit is open or closed.* The two cores now act equally upon the needle, and the distance of its centre from each core is noted; one of the cores is now removed and replaced by the core whose relative strength we would ascertain. Thus the core which remains in one of the helices stands in the place of the "unit-candle" in Bunsen's method of photometry, and the needle which is moved to such a position between the helices that it remains at 0° when the circuit is open or closed, is the equivalent of the paper screen with its central translucent circle.

Among many determinations made with this apparatus, the following are the most interesting:

Comparative strength of similar cores formed of uninsulated and insulated wires.—It was found that a core formed of 400 well annealed iron wires, making a bundle of 1·64 inches diameter and 10 inches long was ·023 stronger than another core similar to the first in all respects, except that the wires were *insulated* from each other by being coated with paraffine. This result is easily explained by the theory of Ampére, which indicates that there will be more interaction of the magnetic currents in the insulated wire bundle, caused by the reaction of the currents which flow around the insulated wire.

What thickness of tube in fraction of its diameter is equal to a similar solid cylinder, both being magnetized to "saturation."—It was found that a tube (1·68 inches in diameter and 10 inches long) having a thickness about $\frac{1}{8}$th of its diameter, was equal in strength to a similar solid cylinder, when both were subjected to the magnetizing influence of a current which "saturated" both. This fraction, however, does not seem constant, but varies with the diameter of the tube, being greater as the diameter is larger.

Experiments on a tube slit longitudinally.—To determine the influence, if any, of destroying the continuity of the exterior surface of a tube by a longitudinal slit, I obtained a tube of well annealed iron, 1·68 inch in exterior diameter, ·16 inch thick and 10 inches long, and slit in its whole length by an opening $\frac{1}{20}$ inch wide. This opening could be closed at pleasure by placing it in a tightly-fitting piece of iron 10 inches long.

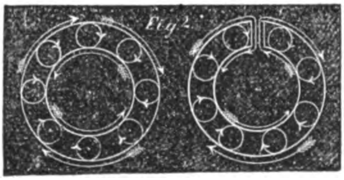
The above tube, with the slit closed, was placed in the E helix, and the 400 wire core in the W helix, and needle brought to such a position between them that it stood at 0° when circuit was open or closed. Eight cells of Bunsen. T. G. 46°.

Slit opened by removing the piece of iron. The needle remains at 0°. T. G. 46°.

Above experiments repeated several times with the same result.

In the accompanying diagrams is shown, according to the theory of Ampére, the direction of the circulation of the exterior and interior surface currents. It is seen, that in both cases, the interior surface current circulates in an opposite direction to the exterior current; and that when the tube is slit longitudinally the circulation is not cut off but *facilitated* by the joining of the exterior and interior surfaces. It is, therefore, natural to suppose that on account of this facility afforded to the circulation that a *quicker* magnetization and demagnetization will occur in the split than in the closed tube; but no difference is found in the magnetic force of the two tubes, for the loss in surface by the slit seems made up in the greater facility of circulation.

Fig. 2.



I would, therefore, suggest that the cores of the electro-magnets of astronomical chronographs, and of telegraph instruments, be of soft well annealed Norway iron, made into tubes having a thickness of $\frac{1}{8}$ of their diameters, and slit longitudinally by a narrow opening.

On the magnetic condition of the interior surface of a tube.—Looking at the above Figs., it is seen that, according to Ampére's theory, currents must flow on the interior surface of a tube in the reverse direction to those which circulate on the exterior surface; and this was shown to be true by many experiments in which not only was a polarity given to introduced cores the reverse of that of the tube, but also by producing a polarity in the tube the *reverse* of that of a helix *introduced into it.*

Beccaria, Coulomb and Faraday have, by their well-known experiments, proved that fractional electricity, when *at rest*, only exists on or just within the outer surfaces of bodies; and Professor Joseph Henry, by many experiments, has shown that this is also true when the same species of electricity, of high tension, is *in motion.* The following beautiful experiment, so conclusive in its evidence, appears so little known, that I will here give it as stated by that philosopher: "A copper wire, of the size usually employed

for ringing door bells, passed through the axis of an iron tube, or a piece of gas pipe, about three feet long. The middle of this wire was surrounded with silk, and coiled into a magnetizing spiral, into which a large sewing-needle was inserted. The wire was supported in the middle of the tube by passing it through a cork at each end, covered with tin foil, so as to form a good metallic connection between the copper and the iron. On the outside of the tube, and opposite each other, were placed two other magnetizing spirals, their ends soldered to the iron. When these two spirals were also furnished with needles, and a discharge from a Leyden jar sent through the apparatus, as if to pass along the wire, the needle inside of the iron tube was found to exhibit no signs of magnetism, while those on the outside presented strong polarity. This result conclusively shows, that notwithstanding the interior copper wire of this compound conductor was composed of a material which offered less resistance to the passage of the charge than the iron of which the outer portion was formed, yet when it arrived at the tin foil covering of the cork, it diverged to the surface of the tube, and still further diverged into the iron wire forming the outer spirals. We must not conclude, however, from this experiment, that the electricity actually passes on the outside of the tube; on the contrary, we must infer, from the following fact, that it passes just within the surface. If the iron be coated with a thin coating of sealing-wax, the latter will not be disturbed when a moderate discharge is passed through it, though with a large discharge in proportion to the conducting power of the rod, the outward pressure may become so great as to throw off the stratum of sealing-wax.

Barlow and Harris have made experiments which show that magnetism is also a surface action; and in Experiment 11 of this paper, we saw that when the surface of a wire core was diminished by compressing the bundle the magnetism diminished with it. To show that this diminution of force was not, in major part, owing to the increased repulsion produced between the bars when brought nearer together, the following experiments were made:—

About 200 $\frac{1}{20}$ inch wires were pressed together as tightly as could be by binding them in a bundle with silken cord, and the deflection they caused in the needle, when magnetized in the helix, was noted; they were now taken apart and bound as tightly as before around a wooden cylinder about 1 inch in diameter; and being magnetized again in the helix with the same strength of current,

the bundle caused a far greater deflection in the needle than when it acted without the central wooden cylinder. I consider this experiment as very conclusive of the surface action of magnetism, for in the two measures we used one and the same mass of metal, subjected to exactly the same magnetizing influence, and only differing in the extent of exterior surfaces existing during the two experiments. That the increase of force with the surface was not owing to a change of distance of the wires from the interior surface of the helix is conclusively shown in the next section.

But there are differences to be made between these analogous phenomena of frictional electricity and of magnetism; in magnetism a *considerable thickness* of metal is required to develop this action at the surface; so that (Ex. 13) a tube must have a thickness of about $\frac{1}{6}$ of its diameter to equal a solid cylinder of the same length and diameter, both being, when compared, "saturated" with magnetism; also, it appears (Ex. 26), that a magnetic action can be effected on the interior surface of a tube, while no similar action can be obtained with frictional electricity.

Experiments to determine whether a change of position of a bar in the interior of a helix causes a change in the intensity of its magnetization.—Theory indicates that no change in the degree of magnetization will follow a change of position of a bar in the interior of a helix, and the following experiments conclusively prove the truth of this deduction.

In the interior of helix E, resting on the bottom of the opening, was placed a cylinder of soft iron ·83 inch diameter and 9 inches long. Opposed to this helix was helix W, in the same circuit, with the 400 wire core. Needle was brought to such a position that it stood at 0° when the circuit was open or closed. T. G. 44½°.

The axis of the iron cylinder was now made to coincide with the axis of the helix. Current passed. Needle still at 0°. T. G. 44½°. Thus showing that the change of position makes no difference in the intensity of the magnetization.

Experiments on the comparative magnetizing effects of a helix and of a combination of spirals formed of similar wire and containing the same number of turns, arranged in a length equal to that of the helix.—According to the theory of Ampère, the currents which encircle a magnetized iron bar or a steel magnet are in planes at right angles to the axis of the bars; and it seemed to me interesting to determine, with this sensitive apparatus, what difference, if

any, existed between the magnetizing effects of a helix whose turns were inclined in the successive layers alternately in opposite angles with the axis, and the effects of a combination of spirals composed of an equal number of turns of wire as the helix and existing in the same length.

Fifty spirals, each composed of 14 feet 8·06 inches of $\frac{1}{20}$ inch wire, in twenty turns, were made by a process to be described in a subsequent communication. These spirals were placed vertically in a frame, at equal distances from each other, so that they formed a cylinder 9 inches in length, 3·9 inches in exterior diameter, and with a cylindrical axial opening of 1·68 inches. The turns of the spirals were carefully insulated from each other by saturating the covering of the wires with melted paraffine.

A helix was constructed of the same wire, wrapped in 20 layers, each layer consisting of 50 turns. The wire in each layer was wrapped parallel with two lengths of twine, so that the 50 turns in a layer occupied a length of exactly 9 inches. This gave a "pitch" to the turns of the helix of ·18 inches, and the innermost turns of the helix formed an angle of 1° 57′·25, and the outside turns formed an angle of 50′·5 with the axis of the helix, alternately to the right and to the left, as it was wrapped. Each layer of turns of wire and twine was carefully saturated with melted paraffine of a high temperature, so that the copper was seen through the saturated covering after the paraffine had solidified.

The helix and combination of spirals were placed 8 feet apart, and an uninsulated 400 wire core placed in each. The compass was placed midway between them, and the needle brought to 0°. The current was now passed so that the N pole of the cores faced the compass. The S end of the needle was slightly deflected toward the helix, showing that the core of this was somewhat stronger than that of the spirals.

The greater strength of the helix could not be attributed to the excess of wire it contained over the spirals, for this only amounted to about 2 inches; thinking that the intense inductive action of the spirals on each other might have some influence, the following experiments were made:

Placed the needle between helix and spirals so that it stood at 0° when the circuit was opened or closed. Then I introduced between the spirals 49 copper disks having central openings a little smaller than those of the spirals. This arrangement, as Professor

Joseph Henry has shown, so effectually cut off the mutual inductive action of the spirals, that on passing a current through them, and breaking a mercury contact, the spark of the "extra current" was (on account of the greater resistance of the spirals) less than when only the circuit of the battery-wires was similarly broken. With the exception of the interposed copper disks, things remained as in Exp. 33. Current passed. Needle remained at 0°. Showing that the inductive action had no influence on the intensity of the magnetizing effect. I am, therefore, of the opinion that the increased effect of the helix was due to superior insulation.

The combination of 50 spirals was separated into two, each containing 25 spirals. Between the spirals of one combination were introduced the 25 spirals of the other, so that every alternate spiral belonged to the same combination. If the current is now passed through one of the combinations, and the two terminal wires of the other combination joined, Faraday has shown, that the "extra current" in the first combination is entirely given up to second. The spirals thus arranged, with the terminals of the interposed spirals separated, were placed opposite the helix E, and distant 8 feet, and the needle so placed between them that it stood at 0° when the circuit was open or closed. On connecting the terminals of the interposed spirals and passing the current, the needle remained at 0°. Thus conclusively showing that *in a combination of spirals, or in a helix, the inductive action of the wire on itself or of adjoining spirals or turns on each other has no effect on the power of their magnetization, and, therefore, no effect on the intensity of the current passing through them.*

I do not remember ever having seen a solution of this question, and these experiments have given it under conditions of a very strong inductive action, and with a very delicate apparatus for detecting any effect which might have been produced. The result is one which has an important theoretic bearing on dynamical inductive action, but I reserve for another communication my views on that point.

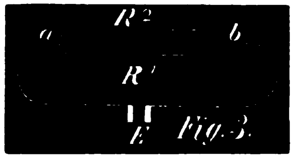
In bringing this research to a conclusion, I think I may safely say, that these results and experiments have shown the delicacy and precision of this method of comparing and measuring the electro-magnetic forces; and at a future time I propose using it to solve the problems which relate to the variation of the intensities of cores with their diameters and with their surfaces, and to examine the varying magnetizing effects of helices of different lengths, diameters and number of turns of wire, and traversed by currents of various intensities.

ABSOLUTE SYSTEM OF ELECTRICAL MEASUREMENTS.

By Josiah P. Cooke, Jr.

(Concluded from page 347.)

23. *Application to a Simple Shunt.*—In Fig. 3 let E represent the electro-motive force of the voltaic element which determines a current of strength C; let R represent the total resistance in the main conductor *a* E *b* through which the whole current flows: let R_1 and R_2 represent the resistances of the two conductors *a* R_1 *b* and *a* R_2 *b* through which flow the two derived currents C_1 and C_2, respectively. We have then by the first of Kirchhoff's laws whether we consider the points *a* or *b*.



$$C = C_1 + C_2 \text{ or } C - C_1 - C_2 = 0, \quad . \quad . \qquad [24.]$$

The second law now gives us—

$$C\ R + C_1 R_1 = E, \quad . \quad . \quad . \quad . \qquad [25.]$$
$$C\ R + C_2 R_2 = E, \quad . \quad . \quad . \quad . \qquad [26.]$$
$$C_1 R_1 - C_2 R_2 = 0, \quad . \quad . \quad . \quad . \qquad [27.]$$

From [25] and [26] we at once deduce—

$$C_1 = \frac{E - C\,R}{R_1}, \text{ and } C_2 = \frac{E - C\,R}{R_2}.$$

Then substituting these values of C_1 and C_2 in [24], we obtain further—

$$C - \frac{E - C\,R}{R_1} - \frac{E - C\,R}{R_2} = 0,$$

and lastly by reduction we find that—

$$C = E\,\frac{R_1 + R_2}{R\,R_1 + R\,R_2 + R_1\,R_2}, \quad . \quad . \quad . \qquad [28.]$$

We can now, by substituting this value of C in [25] and [26], obtain the corresponding values of C_1 and C_2 as follows:—

$$C_1 = E\,\frac{R_2}{R\,R_1 + R\,R_2 + R_1\,R_2} \quad . \quad . \quad . \qquad [29.]$$

$$C_2 = E\,\frac{R_1}{R\,R_1 + R\,R_2 + R_1\,R_2}, \quad . \quad . \quad . \qquad [30.]$$

The well known effects of shunts are direct inferences from these equations. Thus from [29] and [30] we obtain—

$$C_1 : C_2 = R_2 : R_1, \quad . \quad . \quad . \quad . \quad . \quad . \qquad [31]$$

That is the strengths of the currents in the two branches are inversely proportional to the resistances in the two channels into which the main stream divides.

By comparing [28] with [29] or [30] we have—

$$C_1 : C = R_2 : R_1 + R_2 \text{ and } C_2 : C = R_1 : R_1 + R_2.$$

$$C_1 = C\frac{R_2}{R_1 + R_2}. \quad C_2 = C\frac{R_1}{R_1 + R_2}, \quad . \quad . \qquad [32.]$$

Hence the fraction of the stream, which passes through a derived circuit, or, in other words, the reducing power of a shunt is found by dividing the resistance of the shunt by the resistance of the shunt plus that of the derived circuit. If, for example, in Fig. 3, R_2 is the resistance of a galvanometer equal to 99 Ohms and R_1 the resistance of a shunt equal to 1 Ohm, then only $\frac{1}{100}$ of the primary current will pass through the galvanometer, and the shunt reduces its effect on the instrument to that extent.

Finally, we can readily find the *equivalent resistance* of such a branched circuit; for we know by Ohm's law that the total resistance of the whole circuit, including the battery, is—

$$R_0 = \frac{E}{C},$$

and from this we obtain, by substituting the value of C from [28.].

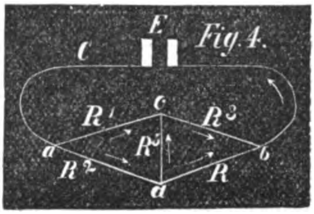
$$R_0 = R + \frac{R_1 R_2}{R_1 + R_2} = R + \frac{1}{\frac{1}{R_2} + \frac{1}{R_1}}, \quad . \qquad [33.]$$

The last term in the above expression evidently represents the equivalent resistance of the two branches R_1 and R_2. If there were three branches instead of two the value would be—

$$R_0 = R + \frac{1}{\frac{1}{R_3} + \frac{1}{R_2} + \frac{1}{R_1}}, \quad . \quad . \quad . \qquad [34.]$$

and hence in general the *equivalent* or joint resistance of any number of branches may be found by adding together the reciprocals of the resistances of each branch and taking the reciprocal of this sum.

24. *Wheatstone's Bridge.*—We have represented in Fig. 4 a system of derived currents, devised by Sir Charles Wheatstone, which is very much used for comparing the resistances of different wires. The battery current C divides at a into two branches $a\ c\ b$ and $a\ d\ b$. Two intermediate points c and d, on these branches are connected by a conductor, which includes a galvanometer. This conductor is called the bridge, and it can be shown that no current will flow over the bridge when the resistances of the several parts of the circuit are such that—



$$R_1 : R_2 = R_3 : R_4, \quad . \quad . \quad . \quad . \qquad [35.]$$

Furthermore, as the galvanometer indicates the smallest current, we can tell when, on varying the resistances, we have reached the condition of equilibrium, and we have then the means of calculating the fourth resistance, assuming that the other three are known. In practices R_1 and R_2 are usually resistance coils of definite values, while R_3 is a set of coils, whose resistance may be varied at pleasure and R_4 is the conductor whose resistance is to be measured.

The proportion on which this very accurate method of measurement depends may be easily deduced by a simple application of the laws of Kirchhoff. From the first law we have for the currents meeting at c and d.

$$C_1 - C_3 + C_5 = 0. \text{ and } C_2 - C_4 - C_5 = 0, \qquad [36.]$$

From the second law we have for the circuit a, d, c.

$$C_1 R_1 - C_5 R_5 - C_2 R_2 = 0, \quad . \quad . \quad . \qquad [37.]$$

and for the circuit a, c, b, d.

$$C_1 R_1 + C_3 R_3 - C_4 R_4 - C_2 R_2 = 0, \quad . \qquad [38.]$$

When there is no current between d and c, $C_5 = 0$. Hence in the condition of equilibrium we have by [36]—

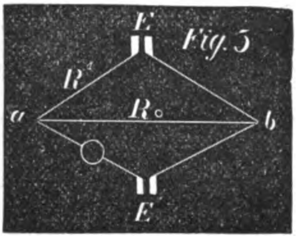
$$C_1 = C_3 \text{ and } C_2 = C_4.$$

Moreover, by [37] $C_2 = C_1 \dfrac{R_1}{R_2}$.

Substituting now these values in [38], we obtain an equation between the several resistances alone, from which we at once deduce—

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}, \text{ or } R_1 : R_2 = R_3 : R_4.$$

25. *Poggendorff's Method* of measuring the electro-motive force of a voltaic element by comparing it with some standard cell is another beautiful application of the theory of derived currents. Two voltaic elements, E and E^1, Fig. 5, ($E > E^1$,) are united by the poles of the same name. Between the points a and b on the connecting wires, we insert a set of resistance coils R_0. We thus establish two associated lines of conductors, first, E, a, b having a total resistance of $R + R_0$, and secondly, E^1, a, b, whose resistance it is not nececessary to consider. In the second circuit is included a galvanometer. When E is greater than E^1 it is possible by varying the resistance R_0, so to neutralize the effect of the weaker element that no current shall pass through the second circuit as will be indicated by the galvanometer. When this is the case we have by Kirchhoff's second law for the two circuits—



$$(1.)\ C\,(R + R_0) = E. \quad (2.)\ C\,R_0 = E^1.$$

Hence—

$$\frac{E^1}{E} = \frac{R_0}{R + R_0}, \qquad . \quad . \quad . \quad . \quad . \quad . \qquad [39.]$$

an equation which enables us to measure E^1 in terms of E, or the reverse, whenever the values R and R_0 are known. The value of R_0 is given by our coils, but since the resistance R is chiefly that of the element E it is difficult to measure it with accuracy. We may avoid the necessity of determining this uncertain element by adding to the part of the circuit E, a, the further resistance R^1. It will then be necessary to increase the resistance of the coils between a and b, to bring the galvanometer to rest. Call this quantity R_1. We shall now have a second equation—

$$\frac{E^1}{E} = \frac{R_0 + R_1}{R + R^1 + R_0 + R_1},$$

and by comparing this with the last, we deduce—

$$\frac{R_1}{R^1 + R_1} = \frac{R_0}{R + R_0}$$

Hence—

$$\frac{E^1}{E} = \frac{R_1}{R^1 + R_1}, \qquad . \quad . \quad . \quad . \quad . \quad . \qquad [40.]$$

CHEMICAL TABLES ACCORDING TO THE THEORIES OF MODERN CHEMISTRY.

BY PROF. LEEDS.

(Concluded from page 350.)

TABLE V.—*Continued.*

MOLECULE.	Sp. Gr.	Molecular Symbol.	Molecular Weight.	Logarithm.	Ar. Co.
Pyrophosphoric Acid	....	$H_4\ O_7\ P_2$	178·	2·25042	7·74958
Phosphuretted Hyd..	1·184	$H_3\ P$	34·	1·53148	8·46852
Platinum..............	20·8 — 21·74	Pt	197·88	2·29641	7·70359
		Pt_2	395·76	2·59744	7·40256
Platinous Chloride...	....	$Pt\ Cl_2$	268·88	2·42632	7.57368
Platinic "	....	$Pt\ Cl_4$	339·88	2·53132	7·46868
Ammo. platinic Chl.	....	$Pt\ Cl_4 + 2\ (N\ H_4)\ Cl$	446·88	2·65019	7·34981
Bario-platinic "	....	$Pt\ Cl_4\ Ba\ Cl_2 + 4H_2\ O$	619·9	2·79232	7·20768
Mag. platinic "	....	$Pt\ Cl_4\ Mg\ Cl_2 + 6H_2\ O$	543·48	2·73518	7·26482
Potas. platinic "	....	$Pt\ Cl_4 \cdot 2K\ Cl$	489·14	2·68944	7·31056
Sodio-platinic Chlor.	....	$Pt\ Cl_4\ 2Na\ Cl + 6H_2\ O$	564·98	2·75203	7·24797
Plumbum (Lead).....	11·36	Pb	207·	2·31597	7·68403
		Pb_2	414·	2·61700	7·38200
		Pb_3	621·	2·79309	7·20691
		Pb_4	828·	2·91803	7·08196
Plumbic Acetate......	....	$Pb\ (C_2\ H_3\ O_2)_2$	325·	2·51188	7·48812
" Carbonate...	....	$Pb\ O_3\ C$	267·	2·42651	7·57349
" Chloride	3·9 H. Rose, 5·54	$Pb\ Cl_2$	278·	2·44404	7·55596
" Chromate....	6·1	$Pb\ O_4\ Cr$	323·54	2·50993	7·49007
Diplumbic Chromate	....	$Pb_2\ O_5\ Cr$	546·54	2·73762	7·26238
Plumbic Nitrate......	4·47	$Pb\ (N\ O_3)_2$	331·	2·51983	7·48017
" Oxide.........	9.36	Pb O	223·	2·34830	7·65170
" Peroxide.....	9·3	$Pb\ O_2$	239·	2·37840	7·62160
" Sulphate.....	6·3	$Pb\ O_4\ S$	303·	2·48144	7·51856
" Sulphide....	6·924	Pb S	239·	2·37840	7·62160
Potassium...............	0·865 A.	K_2	78·26	1·89354	8·10646
		K_3	117·39	2·06963	7·93037
		K_4	156·52	2·19456	7·80544
Potassic Acetate	....	$K\ O\ (C_2\ H_3\ O)$	98·13	1·99180	8·00820
" Bicarbonate...	....	$K\ H\ O_3\ C$	100·13	2·00056	7·99944
" Carbonate......	2·267	$K_2\ O_3\ C$	138·26	2·14070	7·85930
" Chlorate........	2·35	$K\ O_3\ Cl$	122·63	2·08860	7·91140
" Chloride.... ..	1·95	K Cl	74·63	1·87291	8·12709
" Chromate......	....	$K_2\ O_4\ Cr$	194·8	2·28959	7·71041
" Cyanide........	....	K C N	65·13	1·81378	8·18622
" Dichromate...	2·603	$K_2\ O_7\ Cr_2$	295·34	2·47032	7·52968
" Ferricyanide..	....	$K_6\ (Fe\ C_6\ N_6)_2$	658·78	2·81874	7·18126
" Ferrocyanide.	....	$K_4\ (Fe\ C_6\ N_6)$	368·52	2.56646	7·43354
" Fluoride........	....	K F	58·13	1·76440	8·23560
" Hydrate	2·1	K O H	56·13	1·74920	8·25080
" Manganate...	....	$K_2\ O_4\ Mn$	197·22	2·29495	7·70505
" Nitrate	2·058	$K\ O_3\ N$	101·13	2·00488	7·99512

TABLE V—*Continued.*

MOLECULE.	Sp. Gr.	Molecular Symbol.	Molecular Weight.	Logarithm.	Ar. Co.
Potassic Nitrite........	....	$K\ O_2\ N$	85·13	1·93008	8·06992
" Oxide...........	2 656	$K_2\ O$	94·26	1·97433	8·02569
" Permanganate	....	$K_2\ O_8\ Mn_2$	316·18	2·49993	7·50007
" Sulphate........	2·66	$K_2\ O_4\ S$	174·26	2·24120	7·75880
" Disulphate.....	2 28	$K_2\ O_7\ S_2$	254·26	2·40528	7·59472
" Sulphide.......	2·13	$K\ S$	71·13	1.85205	8·14795
Rhodium	11·	R	104.32	2 01837	7·98163
Rubidium	1·52	Rb_2	170·8	2·23249	7·76751
Rubidic Chloride.....	....	$Rb\ Cl$	120·9	2·08243	7·91757
" Oxide.........	.. ..	$Rb_2\ O$	186·8	2·27138	7·72862
Ruthenium.............	11—11·4	Ru	104·2	2·01787	7·98213
Selenium..................	Amorph. 4·25				
	Cryst. 4 8	Se_2	158·48	2·19998	7·80002
Hydroselenic Acid...	2·795	$H_2\ Se$	81·24	1·90977	8 09023
Silicon	2·49	Si	28·02	1·44747	8·55252
		Si_2	56·04	1·74850	8·25150
		Si_3	84·06	1·92459	8·07541
		Si_4	112 08	2·04953	7·95047
		Si_5	140·10	2·14644	7·85356
		Si_6	168·12	2 22562	7·77438
		Si_7	196·14	2·29257	7·70743
		Si_8	224·16	2·35056	7·64944
		Si_9	252·18	2·40171	7·59829
		Si_{10}	280 20	2·44747	7·55253
Silicic Anhydride....	opal, 1·9—2·3				
	qrtz. 2·5—2 8	$Si\ O_2$	60·02	1·77830	8·22170
Chloride........	*5·939 A.1·52	$Si\ Cl_4$	170·02	2 23050	7·76950
Fluoride........	....	$Si\ F_4$	104·02	2·01711	7·98289
Sodium (Natrium)...	0·972 A.	Na_2	46·1	1·66370	8·33630
		Na_3	69·15	1·83979	8·16021
		Na_4	92·20	1·96473	8·03527
Sodic Acetate..........	....	$Na\ O\ (C_2\ H_3\ O)$	82·05	1·91408	8·08592
" Bicarbonate......	....	$Na\ H\ O_3\ C$	84·05	1·92454	8·07546
" Borate.............	....	$Na\ O_7\ B_4 + 10H_2\ O$	359·05	2·55516	7·44484
" Carbonate........	2 509	$Na_2\ O_3\ C$	106·1	2·02572	7·97428
" Carbonate Cryst	1·454	$Na_2\ O_3\ C + 10H_2\ O$	286·1	2·45652	7·54348
" Chloride..........	2·078	$Na\ Cl$	58·55	1·76753	8·23247
" Disulphate.......	....	$Na_2\ O_7\ S_2$	222·1	2·34655	7·65345
" Fluoride..........	....	$Na\ F$	42 05	1·62377	8·37623
" Hydrate...........	2·0	$Na\ O\ H$	40·05	1·60260	8·39740
" Hyposulphite....	....	$Na_2\ O_3\ S_2$	158·1	2·19893	7·80107
" Nitrate............	2·2	$Na\ O_3\ N$	85 05	1·92967	8·07033
" Oxide.............	2·805	$Na_2\ O$	62·1	1·79309	8·20691
" Phosphate, com.	1·525	$Na_2\ HO_4\ P + 12H_2\ O$	358·1	2·55400	7·44600
" Pyrophosphate..	1·836	$Na_4\ O_7\ P_2 + 10H_2\ O$	446 2	2·65953	7·35047
" Sulphate..........	2·46	$Na_2\ O_4\ S$	142·1	2·15259	7·84741
" Sulphide.	1·5	$Na_2\ S$	78·1	1·89265	8·10735
Microcosmic Salt......					
Ammonio-sodic Phos	....	$H\ (NH_4)NaO_4\ P + 4H_2O$	209·05	2·32025	7·67975
Strontium...............	2·54 A.	Sr	87·48	1·94191	8·05809
		Sr_2	174·96	2·24294	7·75706
		Sr_3	262·44	2·41903	7·58097

*Vapor.

TABLE V—*Continued.*

MOLECULE.	Sp. Gr.	Molecular Symbol.	Molecular Weight.	Logarithm.	Ar. Co.
		Sr_4	349·92	2·54397	7·45603
Strontic Carbonate...	3·70	$Sr\ O_3\ C$	147·48	2·16873	7·83127
" Oxide.........	4·611	$Sr\ O$	103·48	2·01486	7·98514
" Sulphate......	3·95	$Sr\ O_4\ S.$	183·48	2·26359	7·73641
Sulphur..................	Rhom. 2·07				
	Monoc. 1·958	S_2	64·	1·80618	8·19382
	Amorp. 1·919				
	* 6·617 A.	S_3	96·	1·98227	8·01773
		S_4	128·	2·10721	7·89279
		S_5	160·	2·20412	7·79588
		S_6	224·	2·35025	7·64975
Sulphuric Acid.........	....	$H_2\ O_4\ S$	98·	1·99123	8·00877
Anhydride	* 3·00 A.	$S\ O_3$	80·	1·90309	8.09691
Sulphurous Acid......	....	$H_2\ O_3\ S$	82·	1·91381	8·08619
Anhydride	2·234	$S\ O_2$	64·	1·80618	8·19382
Hydrosulphuric Acid	1·191	$H_2\ S$	34·	1·53148	8·46852
Hyposulphurous "	....	$H_2\ O_3\ S_2$	114·	2·05690	7·94310
Tantalum	10·78	Ta_2	364·	2·56110	7·43890
Tantalic Anhydride..	7·6—8	$Ta_2\ O_5$	444·	2·64738	7·35262
Tartaric Acid..........	....	$H_4\ O_4\ (C_4\ H_2\ O_2)$	146·	2·16435	7·83565
Neutral Potas. Tart..	....	$K_2\ H_3\ O_4\ (C_4\ H_2\ O_2)$	226·26	2·35460	7·64540
Acid Potas. Tartrate.	....	$K_2\ H_2\ O_4\ (C_4\ H_2\ O_2)$	118·13	2·07236	7·92764
Tartar Emetic Cryst.	....	$K\ (SbO)\ H_2\ O_4(C_4H_2O_2) + H_2O$	343·47	2·53589	7·46411
" " after heating to 200°.....	....	$K\ Sb\ O_4\ (C_4\ H_2\ O_2)$	307·47	2·48781	7·51219
Tellurium................	6·65	Te_2	258·	2·41162	7·58838
Terbium.................	....	Tb_2	75·36	1·87714	8·12286
Thallium................	11·862	Tl_2	408·	2·61066	7·38934
Thallic Oxide	....	$Tl_2\ O$	424·	2·62787	7·37263
Thorium..................	....	Th	238·	2·37658	7·62342
Tin (Stannum)........	7·3	Sn	118·06	2·07210	7·92790
		Sn_2	236·12	2·37314	7·62686
Stannic Chloride......	* 9·199 A.	$Sn\ Cl_4$	260·06	2·41507	7·58493
" Oxide.........	6·72—6·95	$Sn\ O_2$	160·06	2·20428	7·79572
" Sulphide.....	4·6	$Sn\ S_2$	182·06	2·26021	7·73979
Stannous Chloride....	....	$Sn\ Cl_2$	189·06	2·27660	7·72340
" Oxide........	6·66	$Sn\ O$	134·06	2·12730	7·87270
Stannous Sulphide....	4·973	$Sn\ S$	150·06	2.17626	7·82374
Titanium................	5·3 A.	Ti	50·34	1·70191	8·29809
		Ti_2	100·68	2·00294	7·99706
Titanous Chloride....	....	$Ti_2\ Cl_6$	313·68	2·49648	7·50352
" Oxide......	....	$Ti_2\ O_3$	148·68	2·17225	7·82775
Titanic Chloride......	....	$Ti\ Cl_4$	192·34	2·28407	7·71593
Hydro-titanic Fluor.		$Ti\ F_4\ 2H\ F$	166·34	2·22100	7·77900
Titanic Oxide..........	Rutile 4·25 Anatase 3·84	$Ti\ O_2$	82·34	1·91561	8·08439
Tungsten................	17·5	W	184·	2·26482	7·73518
		W_2	368·	2·56585	7·43415
Tungstic Anhydride.	7·137	$W\ O_3$	232·	2·36549	7·63451
Uranium.................	18·4	U_2	237·72	2·37607	7·62393
		U_3	356·58	2·55216	7·44784

* Vapor.

TABLE V.—*Continued.*

MOLECULE	Sp. Gr.	Molecular Symbol.	Molecular Weight.	Logarithm.	Ar. Co.
		U_4	475·44	2·67710	7·32290
Uranous Chloride....	....	$U\ Cl_2$	189·86	2·27843	7·72157
Uranyl..................	....	UO	134·86	2·12988	7·87012
Uranyl Chloride......	....	$UO\ Cl_2$	170·36	2·23137	7·76863
" Fluoride......	....	$UO\ F$	153·96	2·18741	7·81259
" Hydrate......	....	$(UO)\ O\ H$	151·86	2·18144	7·81856
" Nitrate.......	....	$(UO)\ O\ (NO_2) + 3H_2O$	246·86	2·39245	7·60755
Native Ox. Uranium.	....	$U_3\ O_4$	420·58	2·62385	7·37615
Black Oxide "	....	$U_4\ O_5$	555·44	2·74464	7·25536
Vanadium...............	....	V_2	102·66	2·01140	7·98860
		V_3	153·99	2·18749	7·81251
		V_4	205·32	2·31243	7·68757
Vanadyl.	....	VO	67·33	1·82821	8·17179
		$V_2\ O_2$	134·66	2·12924	7·87076
		$V_2\ O_3$	150·66	2·17799	7·82201
		$V_2\ O_4$	166·66	2·22183	7·77817
Vanadic Anhydride.	....	$V_2\ O_5$	182·66	2.26164	7·73836
Yttrium................	....	Y	61·7	1·79029	8·20971
Zinc.....................	6·8—7·2	Zn	65·06	1·81331	8·18669
		Zn_2	130·12	2·11435	7·88565
Zincic Carbonate.....	4·1—4·5	$Zn\ O_3\ C$	125·06	2·09712	7·90288
" Chloride.......	....	$Zn\ Cl$	135·06	2·13053	7·86947
" Hydrate........	....	$Zn\ O_2\ H_2$	99·06	1·99590	8.00410
" Oxide...........	5·63	$Zn\ O$	81·06	1·90881	8·09119
" Sulphate.	3·4	$Zn\ O_4\ S$	161·06	2·20709	7·79291
" Sulphat Cryst.	1·9—2·1	$Zn\ O_4\ S + 7H_2\ O$	287·06	2·45797	7·54303
" Sulphide.	3·92	Zn_3	97·06	1·98704	8·01296
Zirconium..............	Cryst. 4·15	Zr	89·6	1·95231	8·04769
Zirconia.................	....	$Zr\ O_2$	121·6	2·08493	7·91507
Zirconic Chloride.....	117·6	$Zr\ Cl_4$	231·6	2·36474	7·63526
" Fluoride.....	....	$Zr\ F_4$	165·6	2·21906	7·78094

But, in truth, it is not the ratio of the basic and acid anhydrides (the mere existence of which as such, in the mineral is hypothetical) that we desire to arrive at, but the ratio of atoms or radicals. This may be obtained by multiplying the quotients of the per cents of the anhydrides, by their molecular weights, into the quantivalences of their contained radicals. If several radicals replace one another, the products thus arising, in the case of these radicals, are to be added together. To the ratio thus obtained, between the several classes of radicals, Prof. Cooke has proposed the name of *atomic ratio.** In order to facilitate calculations, the quantivalence of each element is given in Table IV.

* *Amer. Jour. of Sci.*, Vol XLVII., May, 1869.

To illustrate by an example, we will take this analysis which I made of a feldspar from Chester County, Pa. Multiplying the quotients found as above stated by the quantivalence of each radical:

$$\begin{array}{llll}
Si_2, & 1{\cdot}13 \times 4 = 4{\cdot}52 & = 4{\cdot}52 = & 12 \\
Al_2, & {\cdot}194 \times 6 = 1{\cdot}16 & = 1{\cdot}16 = & 3 \\
Ca, & {\cdot}026 \times 2 = 0{\cdot}05 & \multirow{4}{*}{} & \\
Mg, & {\cdot}003 \times 2 = 0{\cdot}01 & \left.\right\} = 0{\cdot}38 = & 1 \\
Na_2, & {\cdot}143 \times 2 = 0{\cdot}29 & & \\
K_2, & {\cdot}015 \times 2 = 0{\cdot}03 & &
\end{array}$$

This ratio, 1 : 3 : 12, or 2 : 6 : 24, expresses the ratio of the atomicities of the dyad and tetrad radicals. Dividing each member of the ratio by the atomicity of the class of radicals corresponding to it, we obtain the number of atoms of that class. The formula of this feldspar, accordingly, may be written $(Ca, Mg, Na_2, K_2)''[Al_2]^{vi.} Si_6^{iv.} O_{16}$. The oxygen is that which is required to satisfy the atomicities of the radicals, and may be divided in accordance with whatever opinion is entertained concerning the grouping of the atoms in the molecule.

THE SUN.

(A course of five lectures before the Peabody Institute of Baltimore, January, 1870.)

BY B. A. GOULD.

(Continued from page 344.)

WHEN we view the sun through a telescope of moderate power, provided with a deep shade-glass of appropriate tint, or with a solar eye-piece, we see a bright disk, in which no measurement has yet detected any variation from a perfect circle. This circle, which is, of course, the form in which a sphere would exhibit itself, is not of equal brightness throughout, but by reducing the light from all parts, so that differences of brilliancy become conspicuous, the central position is seen to be much brighter than the parts near the circumference, a fact which is also conspicuously manifested by all solar photographs of short exposure. Nor is the solar brightness equable in other respects; but the whole surface appears mottled by small variations in brilliancy which have been compared to the irregularities upon the rind of an orange, and to the uneven surface of a stormy sea.

Usually, too, several spots or groups of spots of irregular and often of fantastic shape are to be seen, variously distributed, but almost always within a belt crossing the sun centrally, and not equal in width to one-half its diameter. These spots differ in size, from the smallest visible one up to a breadth* of 2′, which is $\frac{1}{16}$ of the diameter of the sun, and corresponds to 7 times that of the earth; and a short period of examination suffices to show that their forms and dimensions are undergoing continual and rapid changes. Ordinarily, and indeed always, if of any considerable magnitude, they consist of two distinct parts, each sharply defined, viz., a dark portion, called the umbra or nucleus, and an extensive grayish border, much brighter than the nucleus, called the penumbra.

Sometimes (not often, but on the average about one day in ten,) the sun is seen entirely free from spots, while on other occasions they are extremely numerous, more than 50 having been seen at one time.† Not unfrequently they are visible to the naked eye, through a smoked glass. This is generally the case when their diameter exceeds 50″. Schwabe, a German astronomer, residing in the town of Dessau (to whom we are indebted for assiduous and careful observations of sun spots since the year 1826, being now more than 43 years), states that during the year 1851 no less than 13 spots were visible without the aid of a telescope. The intervals between the several spots of a group often consist entirely of penumbra; and one such group, seen in the year 1847, was more than 11′ (that is, more than $\frac{1}{3}$ the sun's whole diameter) in length.‡

Finally, yet another appearance presents itself to the observer with a telescope of moderate power, viz., bright patches or streaks of light more brilliant than the rest, and not to be confounded with the general mottling of the surface. These are called *faculæ;* they are generally, but not always, of an elongated form, and chiefly manifest in regions near the limb or margin of the sun. There is, however, one variety of them very long and narrow, to which Herschel gave the name of "scars," and which are seen near the central portions. Faculæ may almost always be seen in the close vicinity of spots, especially to the left of them; but they are not restricted to these situations, and may constantly be found in regions where spots are never seen. The fainter light of the sun's margin,

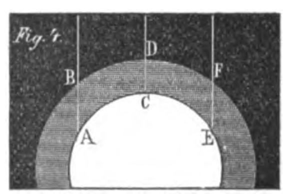
* Winnecke, *Die Sonne*, p. 9, reports a spot 117″ broad, on the 9th December, 1852.

† Herschel, *Phil. Trans.*, 1801, p. 359.

‡ Winnecke, 1847, June, 14.

as well as some other causes hereafter to be mentioned, render them especially conspicuous near the limb or edge of the sun. And it is a frequent occurrence for them to be very manifest upon the eastern side, then gradually to grow less distinct as the sun's rotation brings them nearer to the centre, until they disappear for a few days, to become visible once more as the rotation carries them toward the other side, and finally very conspicuous again before they pass from view around the western margin. (See Plate I.)

These various appearances we will now consider in their order. The inferior brightness at the circumference of the sun's disk has been well known since the first invention of the telescope. The first published mention of it seems to have been by Scheiner, a learned Bavarian professor, who was among the earliest telescopic observers of the sun. He estimated that the diminution of light extended from the circumference inward for a distance of about $\frac{1}{8}$ of the diameter. And even at that early day, he discussed the phenomenon and its origin with a thoroughness by which astronomers of two centuries later would have done well to profit. Some persons had maintained that since the apparently flat disk of the sun is really our perspective view of a hemispherical surface, of which the central portion is nearest to us, the superior brilliancy of this portion should be ascribed to its greater proximity. This view we now know to be incorrect, inasmuch as the fore-shortening of the margin of such a hemisphere compensates for the obliquity at which it is seen; and, even then, Scheiner referred the phenomenon to what is doubtless the true explanation, viz., an imperfectly transparent coating of the sun, situated outside of its luminous surface, and through a greater thickness of which the marginal rays must pass before reaching us. Thus, in the diagram, the luminous sphere, A C E, would appear to the observer as a circle of uniform brilliancy so long as no light-absorbing envelope surrounded it. But, did such an envelope exist, the rays at A B, and at E F, which come to the observer from the vicinity of the border would be much more enfeebled by the surrounding medium than the central rays, like C D, which have only a much thinner stratum to traverse. Now that the existence of a solar atmosphere is beyond doubt, this explanation is seen to



be unquestionably correct, but Scheiner was unable to perceive the thorough applicability of his own views, and came to the conclusion that a full explanation could not be obtained by supposing the diminution of brightness to be proportional to the thickness of the absorbing stratum traversed by the light. He maintained, therefore, that the material through which the light passed became gradually more impure as it became more distant from the centre. Being an earnest Jesuit, he had, of course, a theological illustration ready, and considered that at the last day, when the elements of this earth are to melt with fervent heat, an observer, conveniently and comfortably situated in some agreeable position at an appropriate distance, would perceive the same phenomenon in our planet; since the impure vapors expelled by the intense heat must inevitably give rise to the same appearances ;—the bright glow from the central portions of the earth's disk fading gradually away into a darker ring at the circumference.

The French physicist Bouguer* found the light of the sun's disk, at three-fourths of the distance from the centre to the limb, to be $\frac{35}{48}$ths of that at the centre, and Chacornac† estimated the diminution of brilliancy to begin at about three-tenths of the distance from the centre, and to amount, near the margin, to one-half of the whole light—so that the penumbra of a spot near the middle of the disk is actually brighter than any part of the rim.

Analogous researches concerning the heat of different parts of the sun have led to similar results. Father Secchi, formerly of Georgetown, made at Rome a series of delicate measurements with a thermo-electric apparatus, which gave‡ results accordant with those of Chacornac for the light; and photographs tell the same story for the chemical, or, to use a better word, the photolytic rays. The laws according to which the marginal radiation would be enfeebled by the absorption in an atmospheric envelope, have been thoroughly investigated by La Place and Plana, and are well known.||

A more curious question has been discussed very extensively during the last quarter century, viz: whether, apart from the apparent effect of its atmosphere, any real difference exists in the radiant energy of different parts of the sun. In the year 1844 Prof.

* *Traite d'Optique sur la Gradation de la Lumiere.* Paris, 1760, p. 91.

† *Comptes Rendus*, 1859, Nov. 21.

‡ *Astron. Nachr.* XXXIV, 219.

|| *Mécan. Céleste*, T. IV. 282–88 orig. edit. ; *Astron. Nachr.* XXXIV, 339.

Nervander, of Helsingfors, made a similar announcement.* His investigations into the dates of the annual closing in and breaking up of the ice in the Neva and sundry other rivers had led him to the discovery of a well marked periodicity in their phenomena, by which their early or late occurrence repeated themselves at intervals of about seven years. Examination of the average temperatures of different years threw no light upon the cause of this singular fact, and he finally had recourse to the investigation of periods different from one year, but of which seven years is a multiple. After various trials it occurred to him to assort observations of the thermometer in groups corresponding to the supposed periods of the sun's rotation on his axis. This period was only roughly known, and some difficulty thus arose; but just at this time Laugier's determination was published,† and gave a most satisfactory accordance; and when Nervander came to invest the problem, and from twenty-three years daily observations at Paris, and fifty years at Innspruck, to deduce that period which would best account for the facts observed, he obtained from each series the accordant value, 27·25, which differs by only 0 ·02 from Laugier's result for the sun's rotation. The natural inference was that one-half of the sun emits a greater amount of heat than the other half; and this difference Nervander found to be 0°·6 C. (= 1°·1 F.) The Italian astronomer, Carlini, found that ten years' observations at Milan gave the same result; the German astronomer, d'Arrest, obtained the same from Königsberg observations; and a similar, though a little longer period, from the Berlin ones. But in England, Mr. Airy, the astronomer Royal, failed to deduce corresponding results from Greenwich observations, and Buys Ballot, in Holland, found‡ from the discussion of the Utrecht observations, a period not very dissimilar in length to that of the sun's rotation, yet somewhat too long to be attributed, in his judgment, to this influence. Thus this supposed inequality in the heating power of the two sides of the sun can hardly be regarded as proved.

(To be continued.)

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* *Bulletin Phys. Math.* de l'Acad. de St. Petersbourg, III, 1, 30; also, *Pogg. Annalen*, LXVIII.

† *Comptes Rendus.* 1842. II. 940.

‡ *Poggendorff's Annalen*, LXVIII, 205-213.

OBSERVATIONS ON THE VARIATION OF THE MAGNETIC DECLINATION IN CONNECTION WITH THE AURORA OF OCTOBER 14, 1870.

With Remarks on the Physical Connection between Changes in Area of Disturbed Solar Surface and Magnetic Perturbations.

By Alfred M. Mayer, Ph.D.

THE aurora was first observed by me at 6h. 30m. P. M., as a ruddy glow in the N. N. E., reaching to about 40° above the horizon. The magnetic observations were commenced at 6h. 35m.

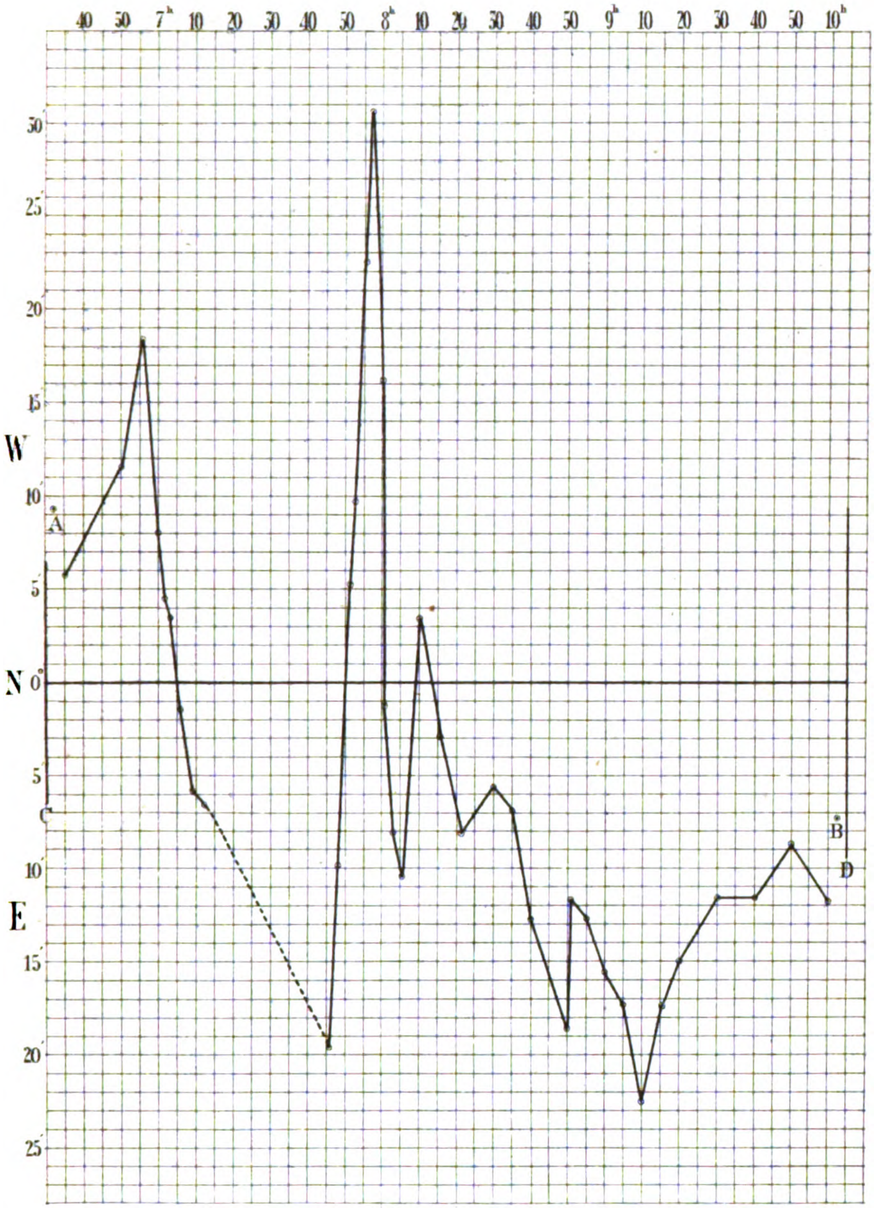
In the following tables the first column contains the times of observation in Bethlehem mean time (long. E., Wash. 6m. 42s., lat. N. 40° 36′ 24″), while in the second are given the declinations, + indicating a W. and — an E movement of the N. end of the magnet in reference to the line of mean declination of the day, taken as the mean of the maximum E. elongation at 8h. 30m., and the maximum W. elongation at 13h. 17m. This line of mean declination we will call 0°.

These determinations are here expressed graphically. The ordinates above the 0° line indicate a W, and those below an E position of the N. end of the magnet referred to the line of mean declination of October 14. The vertical line C shows the average daily range (12′·85) as given by the mean of the range of the five days before and of the five days after the auroral display; not including in the mean the range of October 14th. The line D represents the range (18′·43) of October 14. A is the position the magnet held (+ 9′·33) at 1h. 17m. P. M. on October 14, while B is the declination (— 7′·25) at 8h., (the time of the greatest E elongation) on the morning of October 15th.

It will be observed, on referring to the column of "Remarks" in connection with the curve, that the motion of the needle coincided in its maxima and minima with the greatest activity of the aurora; and the rapid and steady easterly motion, from 7h. 57·5m. to 8h. 5·5m., of 42′·04, is remarkable; viewed in the declinometer it appeared exactly as though a distant disturbing body was gradually receding from the magnet. The flashing up of brilliant streamers at the time of the beginning of this easterly motion is also to be noticed.

The magnet used in these observations is a cylindrical bar, 8 in. long and 0·4 in. in diameter, attached to a plane mirror, 2 inches

VARIATION OF THE MAGNETIC DECLINATION
DURING THE AURORA OF OCTOBER 14. 1870.



square, and suspended by 2 feet of untwisted silk fibres. The scale is placed 3 metres from the mirror, and with the telescope deflections of 10″ can be read.

TIME.	DECLINATION.	REMARKS.
h. m.		
6 — 35	+ 5′·70	An arch of silvery light in the N., whose sagitta appears to be in the magnetic meridian. Clouds on the horizon partly obscure its outline.
6 — 50	+ 11′·46	Arch about 20° in altitude; definition faint. Streamers W. N. W. and E. N. E.
6 — 56	+ 18′·37	Aurora the same as at 6h. 50m.
7 — 00	+ 8′·00	
7 — 02	+ 4′·55	
7 — 03	+ 3′·39	
7 — 6½	— 1′·29	
7 — 9	— 5′·81	Arch very faint; no streamers.
7 — 12	— 6′·96 to — 5′·81	
7 — 46	— 21′·94 to — 17′·23	Streamers of crimson hue E. N. E. reaching to 60° in altitude.
7 — 48	— 12′·72 to — 6′·96	Crimson and greenish streamers N. W. to N. E.
7 — 51½	+ 4′·55 to + 8′·	
7 — 52½	+ 10′·31 to + 11′·46	Greenish streamers extending about 50° above arch.
7 — 55½	+ 21′·83 to + 25′·28	Aurora nearly the same as at 7h. 52½m.
7 — 57½	+ 31′·04 to + 32′·19	
8 — 0½	+ 22′·98 to + 17′·22	This easterly motion of the magnet is steady and rapid. At the same time deep rosy streamers flash up in the N. N. W.
8 — 1¾	— 1′·20	Red streamers have disappeared.
8 — 3¼	— 8′·12	Aurora the same as at 8h. 1¾m.
8 — 5½	— 10′·42	Aurora same as above.
8 — 10	+ 2′·24 to + 4′·55	Crimson glow in N. E.
8 — 16	— 3′·51 to — 2′·36	
8 — 21½	— 9′·27 to — 6′·96	Aurora has declined to a faint white arch.
8 — 30	— 5′·81 to — 5′·24	Faint white streamers from the arch.
8 — 35	— 6′·96	Streamers very faint. Arch ill-defined. Moon is rising.
8 — 40	— 12′·72	
8 — 50	— 18′·48	
8 — 51	— 11′·57	Aurora still fainter.
8 — 55	— 13′·30 to — 12′·15	" barely visible.
9 — 00	— 15′·60	
9 — 5	— 17′·91	
9 — 10	— 22′·52	Aurora invisible.
9 — 16	— 17′·33	" "
9 — 20	— 15′·03	" "
9 — 30	— 11′·57	" "
9 — 40	— 11′·57	" "
9 — 50	— 8′·69	" "
10 — 00	— 11′·86	" "

It is to be remarked that the auroral observations do not comport in accuracy with the observations of declination. Having no assistance, I could only observe from a N. window directly after having obtained the scale readings, therefore there are many phenomena, which appeared in the zenith, and S. of E. and W. which I did not observe.

In connection with the above observations, I will here give an account of a systematic work in which I am engaged, and which furnishes a few facts related to the subject of this paper.

Every day, about 11h., (if clear; if cloudy, at the nearest possible time thereto,) the mean penumbral diameter in seconds of every spot and tache on the Sun is measured. These diameters are then reduced to what they would be if viewed normally. Each of these measures is then squared, and *their sum* gives a number which will vary with the umbral and penumbral areas. These daily numbers are therefore directly comparable quantities of the areas of solar disturbance; at least so far as that disturbance is evinced in the formation of spots. Similar measures are made on all the faculæ I can manage. Remarks are also recorded as to changes in spots and faculæ. In connection with the above measures the daily range of magnetic declination is determined to 10″.

The object of this work is to discover, if possible, a more certainly based physical connection between the daily *changes of area* of solar disturbance and the variation of daily range of declination. It seems that if the ten-year cycle of solar spots has a physical connection with the varying mean yearly range of declination, that such a connection can be detected and satisfactorily established—if not in the special cases of ordinary daily variations of declination, at least in the cases of great magnetic disturbances or "storms," either accompanied or not by auroral displays. But, as a spot indicates—if not entirely, at least principally—an effect of an action which has done its work, we must look more minutely to the *changes in area of disturbance.* For, if the connection exist, it will show itself principally *during* the periods of rapid increase or decrease in area of solar disturbance, and not when a maximum or minimum area has been reached and remains constant.

These remarks are illustrated by measures on the penumbral areas made before and after the auroral displays of the 14th October, and of October 24 and 25.

The declination range on October 11, three days before the au-

rora, was 11′·23, and increased with the area of solar disturbance to the 14th, when it reached 18′·43, and the area-number on this day equalled 17075 ; but on October 15th, the day *after* the aurora, the declination range had *fallen* to 11′·52, while the area-number had reached 18875, showing an increase of 1800 from noon of the 14th to noon of the 15th, *during which interval* the aurora broke forth. On the 16th the range was 11′·52, and the area-number 15795.

On October 20, four days before the auroral display of October 24, the declination range was only 3′·94; the area-number 13748. On October 22d, decl. = 12′·75; area-number = 14732. On October 23, decl. = 11′·53 ; area number = 15991. On October 24, the aurora (as I subsequently learned from the newspapers) was observed at Cincinnati and Cleveland at 5 A. M. I observed, myself, the great disturbance a few minutes before 8 A. M., when I began my magnetic-observations for obtaining the maximum E. elongation. At 11 A. M. the measure of solar disturbance gave 16954, and the observed declination range on that day equalled 44′·79. On October 25th it reached 54′·63.* On October 26, the declination range equalled 14′·26, and the area-number had declined to 11959. Here also we observe that the aurora appeared during the period of increase in the penumbral surface.

These facts, brought forward as illustrations of my remarks, and not as *proof* of the physical connection of disturbed solar area and magnetic perturbation—for that will require almost constant coincidences—show at once wherein lies the difficulty of such a research ;—a difficulty which seems not to have been appreciated by those who have given their energies more to a mathematical than a physical analysis of the connection of the phenomena ;—and that is the frequent impossibility of fixing the *time* at which such a change in area took place. It is very evident, in the first example, that it took place between noon of the 14th and noon of the 15th, but whether it coincided with the auroral display and magnetic perturbation could only have been determined by means of solar measurements, or photographs, taken at several stations differing greatly in longitude. This shows the absolute necessity of several such

*On the 24th the disturbance was greatest between 9 and 10 A. M. On October 25 the greatest perturbations were from 12 M. to 2·56 P. M. During the evening displays of this aurora the needle was only slightly deflected. One hundred and thirteen observations were made by me on this aurora.

stations; and that future research in this direction cannot rely only on the work of the Kew Observatory. Also, the prevalence of cloudy weather in England, especially during the fall and winter months, will add force to the above opinion.

Rapid changes in spot-area are well known to all students of the solar surface; a good example occurred in the largest spot in the S. W. quadrant of the Sun during the time of the memorable eclipse of August 7, 1869. Measurements on two photographs, taken at intervals of about two hours, gave a closing up of the umbra of 2360 miles in a N. E. and S. W. direction. (See my report on the eclipse, in October number of this *Journal.*) The astronomer Wollaston says: "Once I saw, with a 12-inch reflector, a spot burst in pieces while I was looking at it. I could not expect such an event, and therefore cannot be certain of the exact particulars; but the appearance, as it struck me at the time, was like that of a piece of ice when dashed on a frozen pond, which breaks in pieces, and slides on the surface in various directions. I was then a very young astronomer, but I think I may be sure of the fact." Carrington, Hedgson aud Brodie have observed brilliant clouds appear in the neighborhood of spots, and progress with a velocity of over 6000 miles per minute; while Prof. C. A. Young (this *Journal*, November, 1870,) has recently made a most remarkable spectroscopic observation of two such brilliant clouds—together over 130,000 miles in breadth—which in ten minutes had contracted their dimensions to an enormous extent; this, however, judging from analogy, was probably due to vertical motion.

The question now actually presents itself: In case this physical connection between the disturbed solar area and the terrestrial magnetic condition exist, in what does it consist, what is the nature of this connection? Is it owing to an inductive action of the Sun? If so, the magnetic condition of a body depending greatly upon the condition of the surface, that inductive action will vary with the character of its surface If this be the case, then we should take into consideration the probable condition of the hidden solar hemisphere, deduced from preceding observation on it, when it was visible, combined with subsequent ones, when it again appeared. But can we apply such reasoning to a body covered with tumultuous gases heated to an enormous temperature? Does not the connection consist in the action of the solar vibrations sent forth from the chief source of all energy? The experiments of Morichini, Mrs.

Somerville, Zantedeschi, and others were once viewed as conclusively showing the effects produced by these vibrations, sufficient not only to increase the magnetic intensity of natural and artificial magnets, but also to give magnetism to steel needles previously devoid of that property; but the more recent experiments of Biess and Moser cast such doubts over preceding results that the subject has since received but little attention. It is also to be remarked that Faraday, while travelling in Italy, in May, 1814, as private secretary to Sir H. Davy, saw the experiments of Morichini repeated; but their failure was attributed to the misty state of the air.

With our present imperfect knowledge of the various forms of energy existing in the solar emanation, these questions cannot be answered; but the fact that they can be asked, and the fundamental cosmical relations which will be revealed by their solution, is sufficient to induce men of science again to attack this problem, [though its solution baffled all the manipulative ingenuity and philosophical acumen of a Faraday*]—the correlation of the solar emanations and electricity and magnetism.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, September 21st, 1870.

The meeting was called to order at the usual hour, by Mr. Chas. Close, who, in the absence of the President and Vice-Presidents, was called to the chair. The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their meeting held September 14th, donations to the library were received from the Geological Society of London, the Geological Survey of India, the Society of Arts, London, the Steam Users' Association of Manchester, Eng., la Société Industrielle, Mullhouse, France; from Rear Admiral C. H. Davis, U. S. N., Com. B. F. Sands, Washington, D. C., Prof. J. E. Nourse, U. S. N., Edward Young, Statistical Bureau, Washington, D, C., and William Hopper, Esq., Philadelphia. Also, that at a special meeting of the Board, to take action upon the death of Samuel V. Merrick; the following resolutions were unanimously adopted:

*See Life and Letters of Faraday, Vol. II, p. 301, *et seq.*, and p. 351.

Resolved, That the Managers of the Franklin Institute have received, with the deepest sorrow, the announcement of the death of Samuel V. Merrick, Esq., the founder of the Institute, for many years its President, and always its earnest, liberal and devoted friend. Associated as he was with it, in its early strivings for the public confidence and support, participating as he did in all the great enterprises by which it won its way to the high and honorable reputation it now enjoys, his name and character are so mingled with its history, that while the Institute endures, his will be an enduring memory.

Resolved, That the Managers of the Franklin Institute, many of whom have for years been associated with the deceased in the care of its affairs, and in the other walks of life, in all of which he was so distinguished for broad and wise intelligence, for untiring zeal and for greal public spirit, will ever cherish with feelings of proud and affectionate remembrance the honorable and kindly associations which ever distinguished his relations with them.

Resolved, That in token of our sense of the loss we have sustained, the Hall of the Institute be closed on Monday next; that the Managers attend his funeral in a body, and that the members of the Institute be invited to join with them in paying the last earthly tribute of respect to their honored associate and friend.

Resolved, That a copy of the foregoing resolutions be presented to the family of Mr. Merrick, with the cordial expressions of our sympathy with them in their great bereavement.

Mr. J. C. Cresson moved that the resolutions just read be adopted by the Institute, and said:

"As the immediate successor of our lamented friend in the Presidency of the Franklin Institute, I esteem it a privilege to be permitted to respond to the highly appropriate action of the Board of Managers.

"Mr. Merrick, to whom is due the honor of having originated this institution, when in his early manhood, modestly shrunk from its highest office, and gave his voice for a working-man, his senior in years, who thereupon became the first President of the Institute, and continued to fill that office for the remainder of his life, a period of eighteen years.

"Upon the demise of Mr. James Ronaldson, Mr. Merrick became the unanimous choice of the Institute as its next presiding officer. In this capacity he served the Institute most acceptably, wisely and

efficiently, during thirteen years; and then, at his own earnest solicitation, based upon the opinion that rotation in office might be beneficial, he was permitted to retire, and was requested to name his successor. From none of its officers did the Institute receive more valuable aid, both in time, money and wise counsel, than from our departed friend.

"His benevolent acts were not, however, limited to this single object. As the history of his active career has been so well told in the public prints, and is marked by numerous visible monuments, I will not dwell upon it, but will rather narrate some facts connected with his inner life, known to his intimate associates.

"That he was liberal-minded and large-handed is well known to most of us; but his most zealous deeds were carefully concealed by him. I will recount a few instances, the knowledge of which came to me from the recipients of his bounty.

"A narrative in some of the public prints, vouched for by a gentlemen in whom Mr. Merrick reposed confidence, exhibited a scene of distress entirely unknown to him, and upon the day of its publication, Mr. Merrick's check, for the largest sum given by any one, for these sufferers, was handed to the proper parties. No less than three instances of precisely this kind of prompt relief, given without personal application, have come to my knowledge, showing his constant habit of quiet beneficence. In another case, where personal application was made to him, he, upon learning the facts, promptly responded with the munificent offer of $10,000.

"In social and domestic life, he was the centre of the warmest affections; in religion, most liberal to all others; he was, yet, exact in the performance of his own duties.

"These imperfect remarks, Mr. President, may serve to show us the bright example held up by a man free from all bigotry, and ever filled with charity towards his fellow-men.

"Heartily approving of the resolutions of the Board of Managers, I move that this Institute express its hearty concurrence in them as the full expression of its affectionate regard to the memory of its founder."

The resolution was unanimously agreed to.

Prof. A. R. Leeds thereupon read the paper for the evening, upon "A Laboratory for Chemical Research," which called forth various laudatory comments. He likewise announced the discovery of a new mineral from Chester County, Pa., and described its mineralo-

gical position. The name of "Hallite," in honor of the local mineralogist was proposed for it.

The Secretary then read his report upon novelties in science and mechanical arts, after which the meeting was, upon motion, adjourned.

WM. H. WAHL, *Secretary pro tem.*

Proceedings of the Stated Monthly Meeting, October 19th, 1870.

The meeting was called to order by the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting held October 17th, donations were received from the Royal Geographical Society, the Society of Arts, and the Institute of Actuaries, London, and the Steam Users' Association, Manchester, England.

The paper for the evening was then read by Prof. J. Wise, upon the subject of "Balloon Meteorology," and received interesting comments from various members.

The Secratary next read his report upon novelties in science and the arts, upon which the meeting was, on motion, adjourned.

WM. H. WAHL, *Secretary pro tem.*

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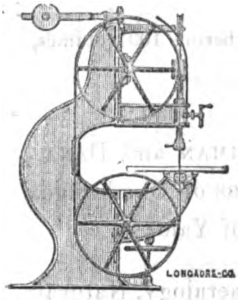

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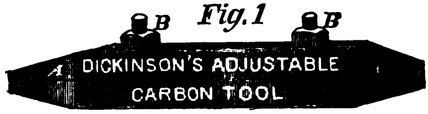
Fig. 1

Fig. 2

Fig. 3

Fig. 1



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See "Scientific American," July 24th, Nov. 20th, 27th, 1869, also Journal of the Franklin Institute, June, 1870.

JOHN DICKINSON,

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10—3m.

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Illustrations—Three Plates and Ten Woodcuts.

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